Adoption of High Value Horticultural Crops in Indonesia: Determinants and Impacts

By

Suprehatin

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

THE UNIVERSITY of ADELAIDE

Global Food and Resources

Faculty of the Profession

The University of Adelaide

December 2016

Acknowledgements

Alhamdulillahirobbal'alamin.

I give thanks to Allah SWT for His grace and blessing during my years of study. Attaining a scholarship abroad and finishing my studies are a miracle that came from Him continuously along with my efforts. There is no coincidence if He wills.

Finishing my thesis dissertation after hard work is an honour and made me realize that I have just begun to be an independent researcher. This thesis would not have been completed without the great support that I have received during my PhD journey. My deepest gratitude goes to my principal supervisors, Professor Wendy Umberger, Professor Randy Stringer, and Dr. Dale Yi, for their advice and support. The opportunity to be part of a great research team inspired me to complete this thesis. A special acknowledgment from me is conveyed to Dr. Dale Yi who has patiently taught me modelling for use in my thesis. I wish to extend special acknowledgment to Dr. Nick Minot who has taught me research skills .and sampling design. Special thanks to Dr. Kate Cadman and to Dr. Robyn Groves, who has given her unconditional support in building my confidence and strength in my academic writing. My appreciation also to Dana Thomsen who has helped me in editing my thesis.

The study was made possible by funding from the Australian Centre for International Agriculture Research (ACIAR) for the post-graduate John Allwright Fellowship (JAF). I thank my Global Food and Resources' colleagues (Sahara, Eka, Risti, Sharmina, Rio, Christian, Dzung, Anna, Laura, Jasmine, Apri, Rahma, Rida, Reyza) for sharing my research journey as well as my friends and my Indonesian colleagues (Dias, Erna, Yoga, Yahya, Rizal, Elizar, PPIA scholars, GoLive scholars and Pak Cody and his family). Special thanks to Wahida and Hery for all the support, discussion and ideas. I want to extend my gratitude to Dr. Arief Daryanto and Dr. Harianto for their discussions and valuable advice. My appreciation also goes to all my colleagues in the Department of Agribusiness, in the Faculty of Economics and Management, Bogor Agricultural University (IPB), Indonesia.

. This thesis is dedicated to my mother, Warsini, and my father, Sapijan. Thank you for raising me with great beliefs and motivation to achieve a higher degree in education. It is also dedicated to my lovely wife, Feb Azimatus Saidah, my children Saujana Ulil Albab, Sausan Asha Khadija and Saundre Ulin Nuha who has provided me with unconditional love, support and understanding. I do enjoy my PhD journey with you all, including having babies. Finally, I dedicate this thesis to my parents in law, Dawam and Siti Amanati, my brothers and sisters, my brothers and sisters in law, and all my nephews and nieces. We do believe, if there is a will there will be a way. Let's grow our future. Bismillah.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma 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 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 consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

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

North Terrace Campus, December 2016

Suprehatin

Abstract

Indonesia, like many developing countries in Southeast Asia, is experiencing an agri-food transformation with rapidly growing demand for high value agricultural products, including horticultural products such as fruits and vegetables. Therefore, there may be opportunities for policy makers to support smallholder farmers to expand their adoption of horticultural crops for their own benefit and for the benefit of Indonesia as a whole. At the same time, however, the Indonesian government needs to maintain intensive support for smallholder farmers to produce adequate supplies of vital staple food crops, such as rice, maize and soybeans, in order to achieve national food self-sufficiency.

This study investigated the opportunities and challenges of expanding horticultural crop production in Indonesia, particularly to improve the participation of Indonesian smallholder farmers in horticultural value chains. The main objectives of this study were two-fold: (1) to examine Indonesian farmer preferences for crop attributes which influence horticultural crop adoption decisions, and (2) to examine how and in what ways small farm household diversification into horticultural production significantly affects farm household livelihoods, namely food supply and income. Four phases of analysis were conducted using unique data from a 2013 survey of 960 Indonesian farmers on Java Island, which has the largest production zone for both horticultural crops and staple food crops in Indonesia.

The first analysis examined the current status of horticultural crop adoption in Indonesia and highlighted the characteristics of farmers who adopted and those who did not adopt a new horticultural crop with respect to the farm household, farm and institutional characteristics. Results showed that horticultural crop adopters were motivated mainly by higher profit, higher yield and greater income opportunities. This study also found that current low rates of horticultural crop adoption are associated with a variety of factors, such

as lower levels of education among farmers, resource constraints, lack of information on horticultural crop production and low participation in farmer groups.

The second analysis focused on Indonesian farmer preferences for specific crop attributes when considering adopting a new crop. This study addresses farmer heterogeneity in preferences for crop attributes at the aggregate as well as group (segment) level. Best-worst scaling analysis showed that the three most important crop attributes for Indonesian farmers at the aggregate level are related to the perceived relative advantage and risks of the new crop, and access to inputs required to grow the crop, such as high quality seeds. Latent class (LC) cluster analysis identified four distinct clusters of farmer segments each with unique socio-demographic characteristics and preferences for crop attributes.

The third analysis examined determinant factors in horticultural crop adoption, particularly the effects of farmer preferences for specific crop attributes on the decision to adopt horticultural crops. After controlling for other factors, multinomial endogenous treatment regressions showed that preference cluster effect varied across models. Product-preference cluster had no significant effect on adoption when measured as a binary variable, that is, to adopt or not adopt. The product-preference cluster had a significant effect on the intensity of adoption and timing of adoption. The effects of farmer crop preference clusters, however, differed across the models.

The fourth analysis explored the impact of farmer adoption of horticultural crops on farm household food supply and income. This novel analysis addressed the trade-offs between horticultural crop diversification and staple food crops. Simultaneous equation regressions showed evidence that horticultural crop diversification decreases the value of non-horticultural crop production and wage income, particularly in lowland areas of Indonesia, but the net effect was positive. While the net effect on total value of food production was higher in highland areas, this study found the income effect to be small.

Table of Contents

List of Tables

List of Figures

1 Chapter One: Introduction

1.1 Background and Motivations

The agricultural food market in Indonesia, as in many developing and emerging economies in Southeast Asia, has been undergoing rapid structural changes over recent decades (Daryanto et al. 2015; Reardon et al. 2015; Reardon et al. 2014). Indonesia's agricultural food markets are transforming significantly towards modern high value agricultural products (HVAP). In other words, HVAP, including livestock products (dairy, eggs and meat) and horticultural products (fruits and vegetables), have been gaining importance in Indonesia, as measured by consumer expenditure (Reardon et al. 2014). Indonesian consumers are demanding more livestock and horticultural products, which indicates that diets are becoming more diversified (Minot et al. 2015; Reardon et al. 2014). The rapid increase in HVAP is driven by economic growth, urbanisation and demographic change in Indonesia. Dietary changes in Indonesian consumption patterns have also been driven by emerging modern retail markets, including supermarkets and agri-food processing industries (Minot et al. 2015; Reardon et al. 2014; Toiba, Umberger & Minot 2015).

Along with meeting changing consumer demand for food, the Indonesian government places equal priority on food security[1], and they are particularly concerned about ensuring domestic supplies of staple crops such as rice, maize and soybean. Currently, the national Indonesian food security policy, known as '*Upsus Pajale*[2]', focuses on encouraging smallholder farmers to expand production of vital staple food crops, rather

[1] In Indonesia, agriculture including staple food and horticultural crop production has been of great significance for food security and national development. At the present day agriculture still represents an important sector of the Indonesian economy. See Daryanto et al. (2015), OECD (2012) and Suryahadi and Hadiwidjaja (2011) for more information about the role of agriculture in the Indonesian economy.

[2] The Government of Indonesia (GoI) has enacted national food security policy to achieve food self-sufficiency for staple crops such as rice (***pa**di* in Bahasa), maize (***ja**gung*) and soybean (*kede**le***), known as *Upsus PaJaLe (Upaya khusus peningkatan produksi padi, jagung dan kedele)*. This policy has been enacted for more than a decade by GoI (see McCulloch & Timmer 2008).

than horticultural crops, such as fruits and vegetables. This is despite growing evidence to suggest that horticulture crops may more profitable for farmers and may offer more lucrative market opportunities (Roy & Thorat 2008; Schipmann & Qaim 2009).

Thus, increasing smallholder production of horticultural crops offers potential widespread benefits for Indonesia, which address national food security by addressing aspects such as access and availability of nutritious food. In Indonesia, smallholders farmers, managing less than one hectare of land, contribute significantly to food production, and also account for a large share (73.4% or 19.2 million households) of the population (BPS 2013). A significant body of previous work has shown that horticulture production, compared to the production of staple food times, has the potential to improve farm household income (Birthal, Roy & Negi 2015; Hichaambwa, Chamberlin & Kabwe 2015; Weinberger & Lumpkin 2007). For example, Babatunde and Qaim (2010), found that higher income farm households are associated with more diversified food consumption patterns, hence improving household nutrition. Thus, incorporating horticulture production smallholder farming systems may well address the "access" (economic access) dimension of food security.

Additionally, increasing smallholder production of horticulture could also improve Indonesia's overall supply of horticultural products, and thus, improve food security by making horticultural products more readily available. Horticultural products are important sources of micronutrients, such as vitamins and minerals (Hughes & Keatinge 2012; Simon, Bowman & Tanumihardjo 2013; Virchow et al. 2015). For example, compared to rice, Chinese cabbage produces 13 times more iron per unit of land per production day, while onion, cabbage and tomato produce three times more, and sweet pepper two times more (Ali & Tsou 1997). Thus increasing horticulture supplies may increase making the price relatively less expensive and improving micronutrient consumption.

Inclusion of smallholder farmers in horticultural crop value chains can lead to employment opportunities in the community. Horticultural crops, such as vegetables, are more labour intensive than other staple food crops, such as rice (Joshi, Joshi & Birthal 2006; Minot & Roy 2007). Recent studies have demonstrated that horticultural crop development may engage more females in the labour force and encourage more women entrepreneurs in production and marketing activities (e.g. Dolan & Sutherland 2002; Maertens & Swinnen 2012; Virchow et al. 2015). Hence, the horticultural sector has potential to create important employment opportunities throughout the value chain from production to marketing, including in rural areas.

Despite growing market opportunities for horticultural crop development, on the supply side, Indonesia's horticultural industry is not without challenges. There are four challenges for developing horticultural value chains in Indonesia. The first challenge is that current horticultural output is unable to meet growing domestic demand although national horticultural production continues to expand. For example, more than 90% of garlic consumption was met by imports, with shallots 15%, oranges 11%, chillies 10% and potatoes 9% (MOA 2014a). Furthermore, fruit and vegetable imports increased significantly over the 10 year period from 2002 to 2011 (FAOSTAT 2014). The second challenge is to improve sustainability and competitiveness of horticultural value chains to meet higher domestic demand and beyond. The third challenge is the dramatic decline of the Indonesian smallholder farm household of horticultural crops who could benefit more from horticultural production. The current National Agricultural Census (*Sensus Pertanian 2013*) showed that the number of farm households engaged in horticultural crop production dramatically declined by 37.4%, from 16.9 million in 2003 to 10.6 million farm households in 2013 (Zakaria et al. 2015). The plausible reason is that farm households moved out of agricultural activities.

Another challenge is that the share of horticultural crops in Indonesian household income decreased from 10.12% in 2004 to approximately 9.9% in 2014, on average (Daryanto et al. 2015). This decline may lead to high increase in production costs of horticultural crops. Another plausible reason for decreased income from horticultural farming is related to high volatility in market prices for horticultural products, and thus high market risk. For example, over the last decade, chilli prices in Indonesia have undergone high month-to-month variability and prices have been extremely low in certain periods (Mariyono & Sumarno 2015).

To respond to these challenges and meet future challenges for horticultural product demand in Indonesia and beyond, policies and programs to promote horticultural crops must be improved. Policy makers need to better engage and support greater participation of smallholder farmers, who make up the majority of Indonesian farmers, to expand adoption of horticultural crops for their benefit and benefit of Indonesia as a whole.

Although previous and current research demonstrates potential benefits for farmers resulting from participation in HVAP, the adoption of new high value crops amongst farmers, including Indonesian farmers, remains low. These low adoption rates are puzzling considering the long history of demonstration and agricultural extension programs, as well as incentive schemes, encouraging adoption of new agricultural technologies.

In response to low agricultural technology adoption rates, significant attention has been placed on better understanding factors influencing smallholder farmer adoption of modern agricultural technologies, such as new varieties, new crops and new farming systems. Studies have suggested four major typologies of factor characteristics that may help to explain lower adoption rate of new/modern agricultural technology (see Doss 2006; Feder, Just & Zilberman 1985; Foster & Rosenzweig 2010; Knowler & Bradshaw 2007; Rogers 2003). These are farmer or farm household characteristics (e.g. age, education, household assets), farm characteristics (e.g. farm size, land tenure), institutional factors (e.g. credit constraint, market access) and technology attributes[3] (e.g. higher expected profit, less labour required). However, most studies still focus on the first three categories to understand determinants of new agricultural technology adoption. For example, a recent study by Abebaw and Haile (2013) focused on the role of cooperatives in accelerating adoption of improved seeds by smallholder farmers in Ethiopia.

Despite previous studies showing the importance of technology attributes in farmer adoption decisions (see Batz, Peters & Janssen 1999; Fliegel & Kivlin 1966; Rogers 2003), few studies have addressed smallholder farmer perceptions of technology attributes when considering adoption of a new technology. More specifically, very few studies, excluding Wahida (2015), have examined farmer preferences for specific crop attributes in the Indonesian context. In fact, a farmer may prefer certain attributes of new crops (e.g. higher profit or increased yield) above others (e.g. labour-reducing or initial costs). In addition, the study by Wahida (2015) on farmer perceptions of crop and farming system attributes, identified unique groups of farmers with similar preferences for certain attributes. This dissertation adds to the existing literature by assessing and evaluating farmer preferences for specific crop attributes when farmers consider adopting a new crop.

Little research has yet investigated determinants of farmer decisions to adopt new agricultural technologies, that is, research has yet to integrate farmer perceptions of specific technology attributes as factors influencing adoption behaviour (e.g. Adesina & Zinnah 1993; Lunduka, Fisher & Snapp 2012; Useche, Barham & Foltz 2009). In addition, development of targeted programs to increase adoption of new horticultural crop technologies requires better understanding of the groups of Indonesian farmers with similar

[3] Previous studies use the term "innovation attributes" (e.g. Fliegel & Kivlin 1966; Rogers 2003), "technology traits" (e.g. Useche, Barham & Foltz 2009), "technology characteristics" (e.g. Adesina & Zinnah 1993). This study uses the term "technology attributes" which may be clearer for a broader readership. However, the underlying meaning is similar.

preferences for crop attributes. Therefore, this dissertation also extends the literature by examining preferences of groups of farmers relating to crop attributes as determinants of farmer horticultural crop adoption.

Indonesian farmer decisions to adopt new horticultural crops may also be affected by national agricultural policy[4]. As explained earlier, the Indonesian government has agricultural policies to ensure national food security and revitalise the agriculture sector by promoting higher value horticultural crop diversification. However, there is currently an emphasis on strengthening production of staple food crops, such as rice, maize and soybean, by smallholder farmers to achieve national food security. This policy may lead to diversion of large resources into staple food production (McCulloch & Timmer 2008) and challenge expanded and beneficial horticultural crop production by smallholder farmers in order to meet higher national demand for staple foods. However, at the smallholder farmer level the specific impact of staple food crop expansion on farm household food production and income is unknown.

At the same time, the impact of horticultural diversification on the smallholder farm households' agricultural production and income is also largely unknown. Most previous studies on horticultural diversification were focused on factors determining diversification both at household level (e.g. Birthal et al. 2013; Joshi, Joshi & Birthal 2006) and national level (e.g. Kumar & Gupta 2015), but studies on its impacts on household food supply and income are under-researched. This study addresses this current research gap relating to the impact of horticultural diversification on farm household food supply and income. This study could help policy makers better promote and support smallholder farmer participation in Indonesia's higher value horticultural chains.

[4] See Basu and Qaim (2007), Doss (2006) and Fisher and Kandiwa (2014) as examples of recent empirical studies suggesting that certain types of government policies or interventions (e.g. subsidies) facilitate adoption of new technologies by farmers.

This study uses a large-scale survey of Indonesian farmers who produce a variety of agricultural crops on Java Island, which has the largest production zone of horticultural and staple food crops in Indonesia. With this variation of sample farmers, this survey includes farmers that have adopted high value horticultural crops in the ongoing transformation of agricultural food markets in Indonesia.

1.2 Research Objectives

This study investigates the opportunities and challenges of horticultural crop production in Indonesia to improve the participation of Indonesian smallholder farmers in horticultural value chains. Specific research objectives of this study are:

1. to describe current practices of horticultural crop adoption in Indonesia and identify different characteristics of adopting and non-adopting farmers with respect to household, production and marketing characteristics;
2. to understand crop attributes Indonesian farmers prefer when considering adopting a new crop and to examine the groups (segments) of Indonesian farmers with similar preferences for crop attributes;
3. to examine determinant factors in horticultural crop adoption, particularly the effect of farmer preferences for specific crop attributes on horticultural crop adoption; and
4. to analyse the impact of farmer adoption of horticultural crops on farm household food supply and income rather than staple crops as encouraged by the Indonesian government.

1.3 Structure of the Thesis

Along with this chapter, this thesis is organised into seven additional chapters. Chapter 2 provides an overview of current literature regarding agricultural technology adoption and crop diversification in developing countries. Empirical studies dealing with determinants of farmer adoption of agricultural technologies are reviewed in order to identify appropriate variables and methods for examining the impact of horticultural adoption. The last section of this chapter provides an overview of the impact of technology adoption on smallholder farmers.

Chapter 3 presents details of methods used in this study. It provides detailed activities of field work completed to obtain data, including development of the questionnaire and sample selection, data entry and cleaning. Chapter 4 deals with the first research objective and describes current practices of high value horticultural crop adoption in Indonesia. This chapter also describes the characteristics of farmers who adopted and those who did not adopt new high value horticultural crops with respect to the farm household, farm and institutional characteristics.

Chapter 5 explores farmer relative preferences for attributes of agricultural technologies related to a new crop, thus addressing the second research objective. A unique best-worst (BW) scaling task is used to assess farmer preferences for crop attributes when a farmer adopts a new crop. This chapter also presents a latent class (LC) cluster analysis to examine whether farmers can be classified into groups or segments that share similar preferences.

Chapter 6 addresses the third objective, to examine the determinants affecting farmer adoption of new horticultural crops. Specifically, this chapter analyses the effect of farmer preferences for crop attributes on adoption of new horticultural crops. The empirical model and econometric results of horticultural crop adoption determinants are presented and discussed.

Chapter 7 examines how farm household diversification into horticultural production affects the value of produced goods and income of the farm household. A simultaneous equation regression model is used to examine the impact of horticultural crop diversification on food supply and household income. In Chapter 8, a summary discussion of study findings and broader implications are presented. Finally, study contributions and suggestions for future research are detailed.

2 Chapter Two: Literature Review

2.1 Introduction

Chapter 1 discussed the ongoing transformation of agricultural food markets in Indonesia and other developing countries. One key aspect of this transformation is potential expansion of horticultural crops, such as fruit and vegetables, not only for large farmers, but also for smallholder farmers. As discussed in the introduction, horticultural crop production offers potential benefits for smallholder farmers to improve their livelihoods.

This chapter discusses previous findings of agricultural technology adoption in agricultural food market transformation. In the case of this thesis, it is important to remind the reader that the term "agricultural technology" refers not only agricultural machinery, but also new crops (e.g. horticulture) and improved varieties of crops, farming systems and post-harvest activities. The purpose of this chapter is to provide a review of the numerous studies that have examined farmer adoption of different agricultural technologies. Thus, the most relevant empirical literature exploring determinants and impacts of agricultural technology adoption are presented and discussed in this study. The goal of this literature review, therefore, is to provide a synthesis of relevant literature and identify gaps in research to date.

2.2 Adoption of Agricultural Technology by Farmers in Developing Countries

Agricultural technology adoption in developing countries is important to enhancing agricultural productivity for food security and poverty alleviation (WorldBank 2007b). Adoption of agricultural technology is also a fundamental driving force for economic development (Barrett, Carter & Timmer 2010; Foster & Rosenzweig 2010).

2.2.1 Different Types of Agricultural Technologies

The majority of adoption studies conducted in developing countries have focused on adoption of improved or new agricultural input technology by smallholder farmers. These studies have covered a wide range of new agricultural input technologies or innovations[5]. These innovations relate to new/modern/improved input technologies, such as high yield crop varieties including hybrid seed (Asfaw et al. 2012; Fisher & Kandiwa 2014; Matuschke & Qaim 2009), pesticides (e.g. Abdollahzadeh, Sharifzadeh & Damalas 2015; Abebaw & Haile 2013), fertilisers (e.g. Krishnan & Patnam 2013; Lambrecht et al. 2014; Yu & Nin-Pratt 2014) and agricultural machinery, including tractors (e.g. Cunguara & Darnhofer 2011; Pingali 2007). In the Indonesian context most such adoption studies are in the Bahasa language and have not been published in English, excluding a study by Winters, Simmons and Patrick (2005). Most existing studies have focused on adoption of new agricultural technologies to improve productivity of staple crops, such as hybrid rice and maize varieties (e.g. Ghimire & Huang 2015; Khonje et al. 2015; Mathenge, Smale & Olwande 2014). Most studies examined adoption of individual technologies in specific production zones that have been promoted by governments to encourage greater production of staple food crops.

Many studies on new farming system technologies, such as integrated pest management (IPM) techniques and organic farming, have focused on sustainability of staple food crop production. Such studies have examined new/modern farming systems or production practices, such as organic farming (e.g. Hossain et al. 2007; Pornpratansombat, Bauer & Boland 2011; Wollni & Andersson 2013), IPM (e.g. Mariano, Villano & Fleming 2012; Parsa et al. 2014), systems of rice intensification (SRI) (e.g. Laksana & Damayanti 2013; Noltze, Schwarze & Qaim 2012) and sustainable agricultural practices (SAP) (e.g. Manda et al. 2015; Ng'ombe et al. 2014; Teklewold, Kassie & Shiferaw 2013). The aim of

[5] According to Rogers (2003), technology is synonymously used with the term innovation.

these studies focused on developing and disseminating ecologically sound and sustainable agricultural technologies, such as IPM techniques, organic fertiliser use and conservation tillage. A common theme in these studies is that many government policy makers have focused primarily on staple food crop production rather than potential benefits of horticultural crop expansion. Thus, greater support is needed for horticultural crop production, particularly in the context of ongoing agricultural food market transformation. Such transformation offers smallholder farmers greater choice to diversify their production portfolio to adopt alternative high value crops to meet requirements of new demand systems and to expand their income (ADB 2013; Reardon et al. 2009).

Numerous studies have been conducted to investigate smallholder farmer adoption of new agricultural technologies responding to ongoing agricultural food market transformation. For example, recent studies have examined smallholder farmer adoption of new marketing channels to enter modern markets (e.g. Hernández, Reardon & Berdegué 2007; Neven et al. 2009; Rao & Qaim 2011; Sahara et al. 2015) and contractual agreements between smallholder farmers and agribusiness firms (e.g. Barrett et al. 2012; Miyata, Minot & Hu 2009; Puspitawati 2013). Such studies have identified new post-harvest technologies enabling greater access to new market channels[6] offering potential benefits for smallholder farmers. The aim of this study focuses on pre-harvest horticultural technologies that may provide benefits based on expanding horticultural crop production.

This study recognises findings of existing Indonesian studies focused on pre-harvest technologies in support of horticultural expansion to include new varieties and farming systems. These findings include adoption studies on certain seed technologies, such as hybrid tomato seeds (Basuki, Adiyoga & Gunadi 2008) and hybrid chilli seeds (Kuntariningsih & Mariyono 2013), and farming system technologies (Wahida 2015).

---

[6] In the literature, authors commonly use the term “participation” rather than adoption (e.g. farmer participation in modern market channels).

Therefore, this thesis adds to the literature by examining adoption of pre-harvest agricultural technology by Indonesian farmers for new horticultural crops as a whole rather than for a single horticultural crop such as chillies or shallots. It provides insights to gain a broad picture of horticultural crops as high value commodities. It can also simplify new horticultural crops as a product category as in fact farmers have greater choices and preferences to grow these crops. In addition, the study contributes to the existing literature by highlighting specific factors which influence the farmers' decision to adopt a new horticultural crop.

2.2.2 Defining Adoption

Previous empirical studies have used various methods to measure adoption behaviour. A household farmer decision to adopt a new technology is commonly described as a binary choice where the farmer could choose to adopt or not adopt. For example, Sahara et al. (2015) used a binary decision to indicate market-channel adoption if the farm household participated in a supermarket channel versus only a traditional market. A survey of adoption literature by Knowler and Bradshaw (2007) showed that approximately half of the studies in the literature used dichotomous measures of adoption. However, binary indicators do not reflect the various aspects of adoption. For example, binary measures of adoption do not explain how intensively farmers adopt new agricultural technologies, nor does it explain the temporal aspects of adoption.

It is useful then to expand adoption indicators, as adoption is complex. Recent studies used non-binary indicators of adoption, such as exploring whether adoption was a continuous process (e.g. Lambrecht et al. 2014; Wahida 2015) and intensity of adoption (e.g. Lunduka, Fisher & Snapp 2012; Vignola et al. 2010).

Instead of simply using a binary indicator of adoption, this thesis incorporates other indicators of adoption, such as intensity of adoption and years of adoption. This is because the adoption of new horticultural crops can include shifting from low value agricultural commodities (e.g. staple crops such as rice, maize, tubers, soybeans) to high value commodities (e.g. horticulture or livestock). This shift is referred to by Reardon et al. (2015) as climbing the value ladder. Often horticultural crop adoption forms part of a diversification strategy, where farmers either shift from producing only staple food crops, towards producing a mix of staple food crops and horticultural crops or producing a mix of many horticultural crops. Farmers may adopt one or more horticultural crops to be included in their agricultural production systems.

Thus, this study contributes to existing research by providing a more detailed understanding of the dynamics of horticultural crop adoption. The use of only binary adoption indicators (e.g. static approaches) in the Indonesian context could be potentially misleading given the dramatic transformation of cropping patterns observed over the past decades in the area under study. Thus this study provides new insights to account for the dynamic nature of adoption and to capture the diffusion process of the agricultural technology, specifically new horticultural crop adoption, over time.

It is important to note that farm households' capacity to support adoption decisions may vary. Adoption of new horticultural crops is not easy for smallholder farmers due to potential constraints regarding specific characteristics of horticultural crops and other factors. Thus, the next section presents literature related to the factors that influence farmer adoption of new agricultural technologies.

2.3 Determinant Factors of Agricultural Technology Adoption

As explained previously, the role of improved agricultural technology is important in developing countries. However, in many cases the adoption rate of modern agricultural technology is low. Therefore, a better understanding of agricultural technology adoption determinants is important as a major component of agricultural growth (Foster &

Rosenzweig 2010). This section reviews the literature related to potential factors that may constrain or encourage smallholder adoption of new agricultural technologies.

An extensive strand of the empirical literature has addressed determinant factors of agricultural technology adoption. On the other hand, there are also seminal works and studies that have summarised previous adoption literature (e.g. Doss 2006; Feder, Just & Zilberman 1985; Knowler & Bradshaw 2007; Prokopy et al. 2008; Rogers 2003). In addition, there is also another seminal work and study that proposed farmer types and adaptations of Ajzen's Theory of Planned Behaviour or attitudes as a different approach to the study of adoption of agricultural technology (see Ajzen 1991; Morrison et al. 2012). Drawing on these seminal works and empirical studies, four major typologies of factor characteristics are identified to help explain low adoption rates of modern agricultural technology. These are technology attributes (e.g. higher expected profit, less labour required), farmer or farm household characteristics (e.g. age, education, household assets), farm characteristics (e.g. farm size, land tenure) and institutional factors (e.g. credit constraints, market access). Each of the four factors are discussed below.

2.3.1 Technology Attributes

A given agricultural technology or innovation embodies a number of important attributes that may influence adoption decisions. Important work by Rogers in 1962 introduced five attributes of innovations to help in assessing different rates of adoption (Rogers 2003). Those attributes were relative advantage, compatibility, complexity, trialability and observability. After Rogers, Fliegel and Kivlin (1966), Tornatzky and Klein (1982) and Moore and Benbasat (1991) addressed more than 25 attributes of innovations, such as cost, communicability, social approval and visibility, rather than Rogers' innovation attributes. These studies proposed better understanding of the effects of technology attributes as they significantly influence adoption of technology or innovation.

However, only Rogers (2003) and Fliegel and Kivlin (1966) focused on agricultural technology attributes.

Previous studies have examined the effects of technology attributes on farmer adoption decisions (e.g. Adesina & Zinnah 1993; Batz, Peters & Janssen 1999; Hintze, Renkow & Sain 2003; Lunduka, Fisher & Snapp 2012). Adesina and Zinnah (1993) showed that farmer perceptions of attributes of modern rice varieties significantly influence adoption decisions in Sierra Leone. Batz, Peters and Janssen (1999) revealed that relative complexity and risk of agricultural technologies are important factors in farmer adoption in Kenya. Hintze, Renkow and Sain (2003) found varietal attributes are significant factors contributing to low levels of adoption of improved maize varieties in Honduras. Birol, Villalba and Smale (2009) identified the significant role of farmer perceptions of technology attributes on adoption decision-making in Mexico. Another study by Lunduka, Fisher and Snapp (2012) demonstrated that specific attributes of different maize varieties are an important factor for farmer adoption in Malawi. Indeed, these studies show the importance of farmer preferences for attributes of new agricultural technologies on adoption behaviour.

The studies under discussion used a different approach from this study to elicit farmer preferences for technology attributes. Adesina and Zinnah (1993) used a farmer subjective assessment to measure dichotomous scales, in terms of yes or no, of preferences for technology attributes. Similarly, Lunduka, Fisher and Snapp (2012) applied dichotomous questions to examine farmer preferences for modern maize varietal attributes. Batz, Peters and Janssen (1999) employed a scoring approach which involved assessments made by extension workers in the study area. Hintze, Renkow and Sain (2003) applied a rating method to each variety using a three-scale method of very good/good, regular/average/sufficient and bad. In summary, those approaches may have potential weaknesses. For dichotomous scales, respondents are required to choose a response that does not exactly reflect their answer and the researcher cannot further explore response meaning. A rating scale may create median responses which often occurs in ranking and rating methods (Balcombe, Rigby & Azapagic 2014).

This study used the innovative method of best-worst (BW) scaling to elicit farmer preferences for crop attributes. A benefits of this method over others is that respondents choose both the best and worst attributes and are forced to make trade-offs amongst subsets of crop attributes. According to Vermeulen, Goos and Vandebroek (2010), BW scaling yields considerably more information about individuals' preferences compared to traditional choice methods. Beyond individual farmer preferences, this study expands to determine groups of farmers who have similar preferences for crop attributes using latent class (LC) cluster analysis.

As discussed above, studies on farmer preferences for technologies and technology attributes should be considered when investigating farmers' needs when making adoption decisions. In addition, farmer needs could be indicative of constraints in adopting new agricultural technology. This study contributes to existing research (e.g. Adesina & Zinnah 1993; Asrat et al. 2010) by providing more comprehensive technology attributes related to production (e.g. water and labour requirement) and market (e.g. price) attributes that drive adoption. Then, these factors are integrated with the other important factors influencing agricultural technology adoption such as farmer, farm and institutional characteristics (Doss 2006; Feder, Just & Zilberman 1985). These characteristics are described in the following section.

2.3.2 Farmer and Farm Household Characteristics

The importance of farmer characteristics in agricultural technology adoption has been widely acknowledged. The broad literature on agricultural technology adoption has suggested three key farmer (or farm household) characteristics that influence adoption of agricultural technology. These factors are human capital, household assets and financial capital. According to the literature, the importance of each factor and direction of influence depends on the nature of the technology (Doss 2006; Feder, Just & Zilberman 1985; Knowler & Bradshaw 2007).

Human capital, such as education, experience, age, and family labour availability, have emerged as variables that potentially influence adoption of improved technologies (Feder, Just & Zilberman 1985; Knowler & Bradshaw 2007). More highly educated farmers are more likely to adopt new agricultural technologies faster, particularly for knowledge-intensive technologies. For example, recent studies by Rao and Qaim (2011) and Sahara et al. (2015) proposed that education is positively correlated with adoption of new modern market-channels, which often require substantial changes in traditional practices. Similarly, more experienced farmers tend to adopt new agricultural technologies (e.g. Kabunga, Dubois & Qaim 2012). A recent study by Ainembabazi and Mugisha (2014) in Uganda found that experience relates positively to adoption of bananas and maize in the early stages of adoption. A younger farmer also tends to be a potential adopter of new agricultural technologies (e.g. Adesina et al. 2000; Nkonya, Schroeder & Norman 1997). Household availability of labour required for adoption is also important. Horticultural crop technologies, for example, are often more labor-intensive, so their adoption depends on family labour availability (Joshi, Joshi & Birthal 2006; Minot & Roy 2007).

Household assets can also influence adoption of new agricultural technologies. Assets deal with whether farmers have the requisite physical (material) essentials for agricultural technology adoption. Productive assets, such as transportation (e.g. a motorbike), agricultural production (e.g. water pump, sprayer and tractor) and storage assets, are commonly captured in studies on agricultural technology adoption (e.g. Feder, Just & Zilberman 1985; Sahara et al. 2015; Wahida 2015). Productive assets are assumed to be positively related to adoption decisions and innovativeness of a farm household (Feder, Just & Zilberman 1985). If a farm household has more assets, it may easier to cope with drawbacks from unsuccessful agricultural technology adoption.

Another farm household characteristic that may play an important role in agricultural technology adoption is financial capital. Farmers are often constrained regarding access to financial resources, such as credit and off-farm incomes (Doss 2006). Finance-constrained farmers are more likely to show slow and low adoption of agricultural technologies, particularly when large investments and inputs are required (Doss 2006; Pannell et al. 2006).

This study includes farm household characteristics in modelling new horticultural crop adoption and its importance in adoption decisions. This study covers farm characteristics, such as farm size and land tenure, as explained in the following section.

2.3.3 Farm Characteristics

The second important factor in adoption of new agricultural technology is farm characteristics. A large body of literature attempts to explain farm characteristics of decision-makers (farmers) that tend to increase agricultural technology adoption. These factors include farm size, land tenure, land ownership structure and supply of complementary farming inputs (Feder, Just & Zilberman 1985; Knowler & Bradshaw 2007). Knowler and Bradshaw's (2007) study concluded that farm size and land tenure (leased) appeared to have different impacts on agriculture technology adoption. However, farm size is often found to significantly influence adoption of agricultural technologies. In addition, in their review, Feder, Just and Zilberman (1985) cited several studies that conclude that renters are less likely than landowners to adopt conservation practices such as conservation tillage and contour farming.

Diversification toward high value horticultural crops may involve constraints related to farm characteristics, particularly those of smallholder farmers. They are often unable to bear larger investment, such as land required to produce horticultural crops. Therefore, this study includes farm characteristics, such as farm size and land tenure, in examining horticultural crop adoption. Another important factor included in the model is institutional or social capital.

2.3.4 Institutional Factors

Institutional factors can influence farmer decisions to adopt new agricultural technologies. From an extensive review of literature on agricultural technology adoption by Doss (2006) and Feder, Just and Zilberman (1985), institutional factors include exposure of extension services, availability of information on new technologies and accessibility of markets for products and inputs. Many studies are concerned with these factors which influence farmer adoption of agricultural technologies and result in various impacts (e.g. Kabunga, Dubois & Qaim 2012; Krishnan & Patnam 2013; Moser & Barrett 2006). However, institutional constraints could generally be a problem for smallholder farmers in adoption of agricultural technologies in developing countries, particularly when the technology is new and not widely known (Feder, Just & Zilberman 1985). Another institutional factor that is important to agricultural technology adoption is farmer membership in producer organisations. A recent study Abebaw and Haile (2013) found that membership in farmer cooperatives has a significant effect on adoption of chemical fertilisers and improved seeds.

Beyond farm, farmer, and household characteristics, external factors can also be important to adoption of new agricultural technologies. These include government policy (e.g. subsidies), infrastructure (e.g. distance to road, distance to markets) and agro-ecological zones (e.g. elevation) (Basu & Qaim 2007; Doss 2006; Feder, Just & Zilberman 1985; Fisher & Kandiwa 2014). In addition, another strand of literature also explores social network, ambiguity, trust and communication (see Barham et al. 2014; Breetz et al. 2005; Maertens & Barret 2013; Morrison, Oczkowski & Greig 2011) as important factors of agricultural technology adoption. These factors, however, were not directly considered in this study as such we did not collect data related to them.

Based on critical examination of adoption literature, characteristics of farmer (or farm household), farm, institutional and technology are among the most important determinants of agricultural technology adoption. However, some studies have focused exclusively on characteristics of farmers, farm and institutional factors, while other studies focused on attributes of technology. Few studies have attempted to understand the relationship between farmer preferences for technology attributes and socio-economic factors shown in previous research to be determinants of adoption.

Several studies have been conducted to integrate drivers and preferences that farmers place on technology attributes (e.g. Adesina & Baidu-Forson 1995; Batz, Peters & Janssen 1999; Hintze, Renkow & Sain 2003; Useche, Barham & Foltz 2009). However, few studies addressed potential endogeneity by farmer preferences for technology attributes and adoption decision (Useche, Barham & Foltz 2009). In other words, there may be causal linkages established between farmer preferences and crop adoption decision. In addition, no similar studies to date integrate those characteristics in adoption models, particularly in Indonesia.

To address this knowledge gap, this dissertation adds to the existing literature by assessing technology attributes influencing adoption decision in the case of horticultural crops in Indonesia. This study introduces the role of farmer preferences for technology attributes into the horticultural crop adoption model. Moreover, farmer preferences for technology attributes in farmer decisions to adopt new horticultural crops are highlighted specifically to determine whether preference cluster factors influence farmers to make the decision to adopt new horticultural crops. In this horticultural crop adoption model, this study includes variables that represent farmer and household characteristics, farm characteristics and institutional characteristics to analyse factors influencing farmer adoption of new horticultural crops. Some variables, such as farmer age, education, experience in horticultural farming, land, and ownership capital, are also elaborated and expected as determinant factors of new horticultural crop adoption. This integrated adoption model is expected to provide better understanding of new agricultural technology adoption by smallholder farmers, resulting in improved livelihoods for smallholders.

The second important issue regarding adoption of new agricultural technologies is potential impacts on household farmers. It is well established that production of high value commodities is more remunerative as compared to staple food crops, such as rice and maize. However, diversification by small farmers into high value crops that can raise farm incomes has also been in question for several reasons, such as diseconomies of scale and lack of access to inputs, such as capital and information, and markets (Birthal et al. 2013). The next section presents empirical studies exploring the impact of agricultural technology adoption on farm household livelihoods.

2.4 Impacts of Agricultural Technology Adoption on Farmers

In general, new agricultural technologies have potential beneficial impacts for household farmers to improve yields, income, food security and livelihoods. The impacts of adoption by farmers in developing countries are relatively well studied for a wide range of new technologies. While some studies have examined the impact of adopting improved or modern varieties of crops (e.g. Bezu et al. 2014; Kassie, Shiferaw & Muricho 2011;

Mathenge, Smale & Olwande 2014; Mendola 2007), others studied the adoption of new farming practices (e.g. Noltze, Schwarze & Qaim 2012; Takahashi & Barrett 2013; Teklewold, Kassie & Shiferaw 2013) and introduction of new or improved agricultural equipment, such as tractors and granaries (Cunguara & Darnhofer 2011). Previous studies have demonstrated that agricultural technology adoption has the potential outcome of improving farmer livelihoods in relation to household income.

For example, Mendola (2007) highlighted that adoption of high yield varieties (HYVs) of rice has a positive impact on farm household poverty reduction in rural Bangladesh. Bezu et al. (2014) showed that improved maize adoption as an innovation has a strong impact on farmer welfare including income. A recent study by Takahashi and Barrett (2013) in Indonesia revealed significant impacts of systems of rice intensification (SRI) on yield gains among farm household, and as a result increased household incomes. Becerril and Abdulai (2010) found a positive impact of improved maize variety adoption on farm household welfare measured by per capita expenditure and poverty reduction in Mexico. Another study by Shiferaw et al. (2014) demonstrated that adoption of modern wheat technology increased food security among smallholder farmers in Ethiopia. Indeed, these studies show that producing staple food crops, such as rice and maize, were good for household food security and for national food security.

Alternative high value crops including horticultural crops, such as fruits and vegetables, may offer greater potential benefits. As explained in Chapter 1, a rapid agricultural food market transformation in Indonesia presents farmers with greater choices to adopt an alternative high value crop to meet new demand systems and expand their income. In addition, horticultural crop production provides diverse food supply sources, particularly as a source of micronutrient-dense food (Hughes & Keatinge 2012; Virchow et al. 2015).

Although there is a wide range of potential benefits of horticultural crops, as described in Chapter 1, there are very few empirical studies which have focused on the impact of high value horticultural crop adoption on household livelihoods. Exceptions are studies by Birthal et al. 2013; Birthal, Roy & Negi 2015; and Minot & Roy 2007. For example, a recent study by Birthal, Roy and Negi (2015) showed that crop diversification into high value crops can reduce poverty for farmers in India. Minot and Roy (2007) highlighted that smallholder farmer participation in horticultural value chains has a positive impact on household income. However, these studies examined the impact of horticultural crop adoption on household income at the aggregate level. In other words, they did not examine the impact of horticultural crop adoption on each source of household income, particularly on-farm income. In addition, several papers on the impact of high value agriculture in developing countries have been descriptive and lacking rigorous analysis using secondary data (Barghouti et al. 2004; Minot & Roy 2007; Weinberger & Lumpkin 2007).

Other previous studies on crop diversification have shown positive correlations with smallholder livelihoods, particularly with respect to household income (e.g. Ibrahim et al. 2009; Pellegrini & Tasciotti 2014; Sichoongwe et al. 2014), but these studies did not specifically examine horticultural crop diversification. A study by Islam and Ullah (2012) using descriptive statistical analysis showed that diversification increases agricultural production, helps grow industries, reduces unemployment, increases supply of nutrition and protein, and import substitution.

Contrary to these studies, a recent study by Narayanan (2014) proposed that participation in higher value agriculture is not always associated with higher economic benefits to smallholder farmers. A study by Hernández, Reardon and Berdegué (2007) also found no significant difference in profits amongst tomato farmers in Guatemala regarding new modern market channel adoption. Therefore, based on empirical studies, whether horticultural crop participation can raise farm household income remains questionable considering potential constraints, such as lack of access to production inputs and markets.

In the Indonesian context, limited studies have investigated adoption of high value horticultural crops and its impact on farmer household incomes. Also, existing studies primarily investigated adoption of specific horticultural crops. For example, a recent study by Sahara et al. (2015), focused on chilli farmers and showed that per capita household income for chilli farmers adopting new market channels in Indonesia is much higher than that for households selling to traditional markets.

Another important aspect of the impact of horticultural crop adoption is how trade-offs impact farm household food supply. For example, how much staple food supply is lost when a farm household expands horticultural production? This issue is especially under-researched. Horticultural crop adoption may divert household resources to horticultural crop production with unknown implications.

Thus, this research also contributes to the scholarly literature by examining trade-offs between horticultural adoption (expansion) and staple food supply in Indonesia. Could diversifying production to include horticulture crops provide more benefits to farmers than if they focused only on staple food crop production?

This study adds new information to the existing literature by examining the economic impacts of high value horticultural crop adoption in Indonesia. Consequently, this study estimates the impacts of adoption on farm household food production and income using unique primary data and robust estimation methods. The study disaggregates food production and income into different categories: horticulture, staple foods and estate crop income. For income, the study adds non-agricultural income, such as wage income. Such study is important to gain a broader picture, to compare and identify trade-offs. It is also useful to distinguish the impact between different agro-ecological zones as different areas, particularly as lowland areas may be less favourable for horticultural production in Indonesia. Hence, the impact between these different agro-ecological conditions may also differ.

2.5 Summary

The adoption of new technologies plays an important role in the agricultural development process to alleviate poverty and food insecurity in developing countries. Therefore, it is not surprising that a dynamic body of literature attempts to understand factors influencing smallholder farmer adoption of agricultural technologies and whether they accept beneficial technologies, and if so why or why not.

This chapter presented a literature review examining adoption of agricultural technologies, determinant factors and potential impacts of smallholder adoption of technologies, including high value agricultural crops. Most adoption studies examined adoption of an individual farm technology in a specific geographical area. Such studies have explored factors influencing farmer adoption of new technologies in developing countries. Explanatory factors vary from study to study based on contextual applicability and specific local condition. While some studies focus on the importance of observable variables, such as farmer characteristics (e.g. education, age) and farm characteristics (e.g. farm size), others examine the role of institutional factors (e.g. credit constraints, market access) as determinants of farmer adoption decisions. On the other hand, several studies show the importance of technology attributes in farmer adoption decisions. Some studies also suggest that certain types of government interventions (e.g. subsidies) facilitate the adoption of new technologies by farmers.

This study contributes to this body of literature with respect to: (1) type of adoption; (2) measures of adoption; (3) determinant factors of adoption; and (4) the impact of adoption on livelihoods. First, the study examines the adoption of new horticultural crops in general as an individual farm technology rather than focusing on just one specific horticultural crop such as chillies or shallots. Second, this study measures adoption as more than a binary decision, using additional measures of adoption including intensity and duration of adoption. Third, this study contributes to the literature by integrating all characteristics, such as farmer (farm household and attitudinal characteristics), farm, institutional and technology, into horticultural crop adoption. Incorporating farmer perceptions of crop attributes into the adoption decision model sheds light on what is important to farmers when considering whether or not to adopt a new crop. Fourth, the study expands the literature by examining the impact of horticultural adoption on the smallholder farm household agricultural production and income. Examining horticultural crop adoption by incorporating farmer preferences for crop attributes provides a better understanding of horticultural crop adoption by smallholder farmers. Examining the impacts of horticultural diversification on farm household food supply and income offers a better understanding of the benefits for Indonesian farm households. In addition, it also provides a better understanding of how to achieve sound horticultural policy for smallholder farmers and Indonesia as a whole.

3 Chapter Three: Methodology

3.1 Introduction

This chapter describes the methods used to design the survey, select the sample of Indonesian farmers and collect data from farm households. This survey was conducted as part of an Australian Centre for International Research (ACIAR) project: "Markets for high value commodities in Indonesia: Competitiveness and Inclusiveness". This chapter begins with questionnaire development and is followed by a detailed explanation of the following research activities: training for enumerators, sampling methods, data collection, and data entry and data cleaning. A short overview of data analysis and a summary is presented in the final section.

3.2 Questionnaire Development

The questionnaire was developed from October 2012 to January 2013 to obtain appropriate data that could be utilised to achieve the four main objectives of this study: 1) to investigate adoption of innovations by Indonesian farmers, including a new crop; new or improved crop varieties and new farming systems; 2) to determine the crop attributes Indonesian farmers prefer when considering whether or not to adopt a new crop; 3) to identify opportunities as well as potential issues related to horticultural crop diversification in Indonesia; and 4) to examine the impact of farmer adoption of horticultural crops on farm household food supply and income.

Questionnaire development consisted of several steps: 1) focus groups and in-depth interviews with key informants and stakeholders (e.g. smallholders, traders, local government, extension specialists),[7] 2) development of a draft questionnaire in English and

[7] Two experienced members of the study team, including the author of this dissertation, interviewed staff at the agricultural local government (*Dinas Pertanian*), extension officers and farmers in six selected districts to gain information regarding about current production and marketing activities of high value commodities in Indonesia including high value crop adoption during the last five years.

Bahasa Indonesian; 3) enumerator training (explained in the next section) and additional revisions after consultations with enumerators; 4) pre-testing the questionnaire with farmers and the trained enumerators and obtaining feedback from both farmers and enumerators, and 5) revising the questionnaire to incorporate farmer and enumerator feedback. This process of training and pre-testing involving enumerators and farmers aimed to ascertain whether the questionnaire was relevant and easily understood by farmers with respect to wording and to assess whether all categories and items in the questionnaire were reliable. The final structured questionnaire is presented in Appendix 15.

Survey questions were based on previous related studies and designed to address the research objectives. The questionnaire included 14 modules used to collect information on all members of the household, including socio-demographics, wealth indices, agricultural and non-agricultural activities, social capital in terms of exposure to institutions, perceptions of modern markets, and adoption behaviour, including adoption of new horticultural crops and perceptions of technology traits (attributes). The objectives of each primary module used in this study are briefly described below.

The household characteristics module was used to collect information on general household characteristics, including: household size, composition, gender, age, education levels and main activities (e.g. employment) of each household member. In this study, a household refers to a group of people who reside and eat together most of the time. Each member must live with the others at least six months of the year unless these family members have a new member (e.g. new baby or new in-law). The head of the household is defined as the member who makes the majority of the household's economic decisions.

The housing and asset module sought information on the types, geographical location and ownership of household and agricultural assets. Information was obtained on both current and lagged assets, where "current" refer to assets owned by households in

2013 (at the time of the survey) and “lagged” refers to assets owned five years prior (2008). Agricultural assets included production assets (e.g. spraying equipment), transportation assets (e.g. motorbike, truck), and storage assets.

The agricultural land module collected information on land owned or farmed by members of the household in the three growing seasons just prior to when the survey was conducted in 2013. The three seasons were categorised as follows: rainy season (planting about Oct 2011), 1st dry season (planting about March 2012) and 2nd dry season (planting about July 2012). This information included land size, land use, land characteristics and tenure system. Questions in this module are organised at the farm plot level.

The agricultural production module obtained information related to crop production undertaken by members of the household in prior three growing seasons. The list of all crops grown in each of the three seasons on a particular plot of farmed land was recorded.

Similar to the agricultural production module, the crop utilisation and input use modules were recorded at crop level. These modules covered information regarding the quantity and cost of production for each crop grown by the farm household. This information was used for generating imputed income from, and total value of, production for each crop in the presence of multi output production. Following these modules, the marketing module sought information on crop sales, post-harvest and market channels. This module also explored the buyer-seller relationship between farmers and buyers and types of contractual arrangements among them.

The production method and marketing information module gathered information about crop production methods, prices and market situation. In this module, crops were grouped into three different categories, namely staple food crops (e.g. rice and maize), horticultural crops (e.g. fruits and vegetables) and estate crops (e.g. sugarcane). The collective action module collected detailed information about household exposure to production-related and market-related collective activities such as farmer groups and cooperatives.

The adoption module covered information about perceptions of innovations, adoption of innovations and intention to adopt an innovation. Innovation refers to the adoption of a new crop, new or improved crop varieties and/or new farming systems. These modules also covered attitudinal questions in relation to risk and time preferences.

The module incorporating the best-worst (BW) scaling task elicited farmer preferences for crop attributes when considering whether to adopt a new crop. Eleven choice tasks were presented to respondents. Each card contained five different crop attributes and respondents were asked to choose the best (most important) and worst (least important) attribute on each card.

The cash income activity obtained an estimate of net cash income from different economic activities, including agricultural and non-agricultural activities. This section also gathered information on change in income sources over time.

3.3 Training of Enumerators

Eighteen experienced enumerators were recruited to carry out the farmer survey. As mentioned in the previous section, each enumerator was trained to ensure understanding of the questionnaire, and ensure that all enumerators understood how to implement each module appropriately. Training was conducted in a six-day session from 20 to 25 January, 2013 in Bogor, Indonesia. Two experienced members of the study team from the University of Adelaide, who were fluent in both Bahasa Indonesian and English (including the author of this dissertation), supervised and conducted the training. The first four days of training focused on understanding the objectives of the survey and questionnaire. On the fifth day, the enumerators and the study team visited the field to conduct a pre-test and interviewed farmers. On average, each enumerator spent 80 to 100 minutes to complete an interview. Feedback for each question during training and field-testing was incorporated into the final questionnaire. The valuable feedback from enumerators was based on their experience conducting farmer surveys in Indonesia. In addition, feedback was incorporated into the questionnaire manual to provide more detailed explanation for certain terms. This manual was very important as a guide for enumerators during data collection and data validation.

3.4 Sample Selection

A sample of 960 Indonesian farmers from Java Island was drawn using a four-stage random sampling process. The area on Java Island from which the sample was drawn is the largest production zone for horticultural crops (fruits and vegetables) and rice in Indonesia. More than half of Indonesian household farmers, including horticultural farmers (60.4%), are located on Java Island (BPS, 2013). In addition, this study area appropriately represents a region that is experiencing rapid economic growth, increasing household incomes, urbanisation and food market transformation[8] (WorldBank 2007a). This study assumed that the unique characteristics of the research area may influence technology choices amongst farmers, including new high value horticultural crop adoption.

This study used distance to major cities[9] and elevation for stratification. Distance was used as a proxy for improved market access, which was based on the hypothesis that adoption of horticultural crops and marketing opportunities would be greater in areas closer to cities. Elevation stratification was used based on the hypothesis that adoption opportunities and crop marketing patterns are likely to be affected by elevation (agro-ecological zones (AEZs)). This stratified sampling method is important if adoption rates of new high value commodities are too low to obtain a sufficient number of adopters in a

[8] These rapid changes are associated with the growing demand of high value agricultural products including fruits and vegetables (Maertens, Minten & Swinnen 2012; Reardon et al. 2009).
[9] This study uses the criterion of major cities in Java with more than 500,000 inhabitants.

completely random sample. This sampling method has also been used by several previous adoption studies (e.g. Crost et al. 2007; Qaim et al. 2006) to ensure that the study area was not clustered spatially or selective of households by socioeconomic status.

A detailed four-stage sampling selection process to obtain a sample of farmers was conducted. First, districts on Java Island were listed and sorted based on nearest to farthest distance to major cities, then six districts (*kabupaten*) were selected randomly. Steps of the systematic random sampling method in selecting districts were as follows:

1. The study team listed cities on Java with a population of at least 500,000 people. As explained above, this study assumed that these cities represent growing market opportunities for high value agricultural products such as fruits and vegetables.
2. The study team listed 75 districts on Java including their distance to the nearest cities and sorted them from nearest to the farthest (Appendix 1). These districts consisted of productive agricultural land currently used for agricultural activities and included farmers that have cultivated agricultural crops of any type.
3. The study team calculated the interval of districts by dividing the total districts and number of selected districts. This approach allowed the inclusion of a significant amount of variation in distance to market by farm households.
4. The study team selected districts by using a 'random starting point' to determine the initial district selected. The second district was selected by adding the starting point plus one interval and the third selected district was the starting point plus two intervals, and so on.

Distance of the six selected districts to major cities varied greatly. The selected districts, ordered by distance to nearest major city, are Tasikmalaya (8 km), Demak (26 km), Subang (42 km), Jombang (62 km), Tulungagung (80 km) and Rembang (106 km). The six selected districts included two in East Java province, two in Central Java province, and two in West Java province.

In the next stage, a sampling selection process developed elevation stratification using a topographical map. The study team listed average elevation at the sub-district (*kecamatan*) level. Following this process, the team sorted sub-districts from lowest to highest elevation for each selected district. Prior to sub-district selection, the study team visited each selected district's head office[10] and interviewed staff in order to obtain verification of elevation. As a result, three districts, namely Demak, Jombang and Tulungagung, were identified as having little variation in elevation. A detailed list of elevation is presented in Appendix 2. For each of the three districts identified, the study team randomly selected four sub-districts without stratification within those districts. Additionally, the team selected four sub-districts that were stratified by elevation category in other districts, namely Subang, Tasikmalaya and Rembang. In Subang, the study team stratified two groups: (1) low land, and (2) low-medium, medium-high and high land. In Tasikmalaya, the study team classified two groups: (1) low, low-medium, and medium land and (2) medium-high and high land. In Rembang, the study team stratified two groups: (1) low land, and (2) low-medium land.

The procedure to choose sub-districts was similar to the procedure in district selections, as explained above. This similar procedure was applied for all districts, including for districts without variation in elevation. This process produced a list of four selected sub-districts in each selected district. The final list of sub-district selection is presented in Appendix 3.

---

[10] The study team visited each selected district office in order to get permission from and to introduce the study team and the enumerators to the local authorities between December 2012 and January 2013. The district directors of the agricultural local office (*Dinas Pertanian*), the sub-district extension officers and the village's representatives were also informed about the research objectives and the survey schedule (February-March 2013).

After all 24 sub-districts were selected the study team listed all villages (*desa*) (Appendix 4). The team members randomly selected four villages within each selected sub-district with a total of 96 villages were selected. In the final step, random selection of farmers from each village was carried out. Team members visited the land tax office, village office or extension office in each of these 96 villages to compile a list of famers planting crops from October 2011 to July 2012. The lists of farmers was based on written records at village level and/or verbal recall by officials. The team randomly selected 10 farm households in each selected village from lists provided by village authorities. A total sample of 960 farm households was obtained from 96 villages across the island of Java. As a backup, the study added an additional ten households from each village.

Table 3.1 presents a summary of selected respondents based on distance to nearest major city and elevation. The majority of respondents, 71.8% of the sample, were located in lowland areas. This is because respondents from three selected districts, namely Demak, Jombang and Rembang, were located on low elevation lands, as explained above. The majority of respondents from Tulungagung were also located in lowland areas.

Table 3.1. Distribution of selected respondents

	Elevation			
Districts[a]	**Low**	**Medium**	**High**	**Total**
Tasikmalaya (8 km)	10	110	40	160
Demak (26 km)[b]	160	0	0	160
Subang (42 km)	80	50	30	160
Jombang (62 km)[b]	160	0	0	160
Tulungagung (80 km)	120	20	20	160
Rembang (106 km)[b]	160	0	0	160
Total	690	180	90	960

Note: [a] Distance to the nearest major city presented in parentheses; [b] Districts have little variation in elevation; This study includes low elevation (<200m), medium elevation (200-600m) and high elevation (>600m).

3.5 Data Collection and Management

The 18 enumerators were divided into three teams of six enumerators and data collection was conducted from 6 February to 17 March 2013[11]. Each enumerator was equipped with the questionnaire manual (handbook) and all choice tasks needed for the survey. For example, enumerators used 11 different choice tasks for delivering the best-worst (BW) scaling task to elicit farmer preferences for crop attributes. All instruments for data collection were provided in Bahasa Indonesian.

The enumerators interviewed selected farmers in their homes or farm fields with most interviews taking 180 to 210 minutes, on average. As the survey was conducted during harvest time in some areas, enumerators had to return to the farm household two or three times depending on farmer availability.

After data was collected it was entered in CSPro and Stata software and cleaned (double-checked and validated) by the research team in Bogor, West Java, Indonesia. The team were experienced and trained in CSPro software. In order to verify whether the data was complete, basic statistical analysis of each question was carried out using Stata software. In some cases, the data entry team asked enumerators for clarification or to follow-up with respondents to obtain further information.

3.6 Data Analysis

Data analyses were conducted to address each research objective, as outlined in Chapter 1. To answer the first objective of this study, survey data was analysed using independent-sample t-tests, as described in Chapter 4. The best-worst (BW) scaling and latent class (LC) cluster analyses as presented in Chapter 5 were used to determine relative importance of crop attributes and examine farmer heterogeneity. In Chapter 6, multinomial

[11] During this period, the study team did a monitoring and supervision in the field to cross-check the data collection process.

endogenous regression analysis is discussed which was used to determine factors affecting farmer decisions to adopt high value horticultural crops. The final analysis used the simultaneous equation regression model presented in Chapter 7 to examine the impact of horticultural crop diversification on household food supply and income.

As explained above, there are different and unique analytical approaches in each discussion chapter. Therefore, the details of each analysis method are explained in each chapter.

3.7 Summary and Conclusions

To address the research objectives of this dissertation, a comprehensive survey of Indonesian farmers producing a variety of agricultural crops was conducted. Development of the questionnaire, which initiated the fieldwork and data collection, involved research teams from the University of Adelaide and the International Food Policy Research Institute (IFPRI). Key informants from the agricultural local government (*Dinas Pertanian*) and extension officers in the six selected districts across Java Island were interviewed for development of the questionnaire.

A stratified random sample of 960 farmers was drawn from 96 villages across Java. The random sample included Indonesian farmers that produced a variety of agricultural crops at varying elevations. Eighteen experienced enumerators were recruited and trained in a six-day program during January 2013. These enumerators collected data by interviewing selected farmers in their homes or farm fields. Primary data obtained during the survey includes a significant amount of variation in production technologies employed by farm households. This study focused on farmers that have adopted high value horticultural crops, such as fruits and vegetables.

The following Chapter presents descriptive statistical analysis to provide insight on horticultural crop adoption in Indonesia. This analysis examines differences in characteristics between adopter and non-adopter farmers in terms of socio-economic, production and marketing characteristics.

4 Chapter Four: Farmer Adoption of High Value Horticultural Crops in Indonesia: Descriptive Statistics[12]

4.1 Introduction

This chapter addresses the first thesis objective: to describe the current practices of horticultural crop adoption in Indonesia. In addition, this chapter discusses differences in characteristics of Indonesian farmers adopting new horticultural crops compared to non-adopters. These characteristics include socio-demographic factors (farmer and farm characteristics), motivation and attitudes to horticultural crop adoption, and production and marketing practices. Understanding motivation and attitudes to horticultural crop adoption, the types of adopters and how and why they differ from non-adopters is important to gain insight into factors that need to be addressed to promote wider adoption of horticultural crops, particularly among smallholder farmers.

4.2 Data and Methods

As described in Chapter 3, this study uses the survey data of 960 Indonesian farmer households. The random sample included farmers that produce a variety of agricultural crops including data of farmers that have adopted new horticultural crops. Basic descriptive statistical analyses, including frequencies and means, were used to describe the current practices of new horticultural crop adoption in Indonesia. This analysis covered rate of adoption, motivation of adoption, change of land use and input use when shifting to a new horticultural crop.

An independent samples t-test was used to compare sample means of adopters and non-adopters with respect to household farm characteristics, institutional factors (e.g. producer organisation membership) and income sources. A Two-sample t-test was used to

[12] The draft of this chapter was prepared for presentation at the 9th International Convention of Asia Scholars, Adelaide, 5-9 July, 2015. Feedback and comments received from conference participants were incorporated in this final version of the chapter.

test whether means were statistically different between adopters and non-adopters (where we are testing H_0: $\mu_1 - \mu_2 = 0$ versus $H_a = \mu_1 - \mu_2 \neq 0$, where μ_1 is the sample mean of adopters and μ_2 is the sample mean of non-adopters) (Black 2009).

4.2.1 Defining Adopters of New Horticultural crops

This study used respondents answers to the question "*Did you start growing any crop for the first time since 2007*?" in the technology adoption module (see Section K in Appendix 15) to classify farmers into new horticultural crop adopters and non-adopters. Therefore, farmers who adopted a new horticultural crop between 2007 and 2012 were classified as 'adopters', while farmers who did not adopt new crops in that period were considered 'non-adopters'. Based on that classification, 101 farm households were classified as adopters and 859 farm households as non-adopters.

As explained in Chapter 2, agricultural technology adoption is not a simple binary decision. Horticultural crop adoption may proceed gradually. The intensity of adoption of a new horticultural crop may increase over time. Some farmers may adopt different horticultural crops over a number of years and others not. Additionally, different horticultural crops may be adopted in different seasons in a year. For example, farmers may grow shallots in the rainy season and grow chillies in the dry season.

In addition to binary measurement, this study developed two other classifications of horticultural crop adoption. The first classification was the horticultural crop component count system, or intensity of adoption, which provided detailed information on the number of horticultural crops adopted by each household. Based on this classification, the average number of new horticultural crops adopted by 960 sample farmers was 0.14.

Another classification was timing of adoption, which indicated what year farmers adopted a new horticultural crop. In enumerating years of adoption by farmers, a value of one to six was assigned if the farmer household adopted a new horticultural crop in 2007 to

2012, consecutively, and 0 otherwise. On average, the years of adoption for a crop was 0.4 years.

4.3 Discussion and Comparison of Adopters versus Non-Adopters

This section presents the results of the comparative analysis of the adopters of new horticultural crop versus non-adopters in Indonesia. This overview includes four topics: adoption rate, dynamics of adoption, motivation to adopt, land use and input use changes when adopting. This section also discusses differences in characteristics between horticultural crop adopters and non-adopters.

4.3.1 Current Practices of New Horticultural Crop Adoption in Indonesia

4.3.1.1 The Rate of Adoption of New Horticultural Crops

Dynamics of Indonesian farmer participation in horticultural crop production are presented in Figure 4.1, which is essentially a horticultural adoption decision tree over time from 2007 to 2012. As Figure 4.1 shows, of the 960 farmers surveyed, roughly 40% of farmers (n = 383) were growing some type of horticultural crop for more than 5 years (2007 or before) and roughly 60% (n = 577) indicated that they were not growing any horticultural crops in 2007. The study can conclude from Figure 4.1 that rates of horticultural adoption are generally low amongst the Indonesian farmers surveyed, with only 10.5% of interviewed farmers adopting new horticultural crops between 2007 and 2012 (Figure 4.1).

All farmers were asked if they adopted any new crops from 2007 to 2012. If they indicated "yes" then they were asked what crops were adopted. A total of 101 farmers (10.5% of the sample) indicated that they had adopted some sort of new horticultural crop between the 2007 to 2012 period. Of these 101 farmers classified as "new horticultural crop adopters" there were 62 of the 383 (16.2%) farmers who had already been producing horticultural crops in 2007 or earlier. Thus, more than a half of "new horticultural crop adopters" can be considered experienced horticulture farmers who grew some kind of other horticultural crop previously. For example, a new adopter may have been a shallot grower in 2007 or earlier and shifted to be a chilli grower between 2007 and 2012.

Of the 577 farmers who did not produce any horticultural crops in 2007, 39 (6.8%) indicated that they "yes" at some stage during 2007 to 2012, they adopted a new crop and that it was a horticultural crop. Therefore the 101 farmers classified as adopters in this chapter are made up of the 62 farmers who were originally producing horticulture crops and the 39 farmers that had not previously produced horticultural crops prior to 2007.

Duration of adoption will also be considered in this thesis. Therefore it is interesting to note that at the time of the survey, of the experienced horticulture producers, three of the 62 who had adopted new horticulture crops and 10 of 321 farmers who had not adopted new crops had stopped producing horticulture crops altogether, leaving an exit rate of experienced horticultural farmers from horticulture over the 2007 to 2012 period of 3.4%. Additionally, the study consider the duration of adoption among the farmers classified as "adopters" in this study. This study also need to consider that of the 39 farmers who adopted horticulture, but that were not originally growing horticulture, 10 were no longer growing horticulture in 2012. Thus, in 2012, 88 of the 101 adopters or 87.1% of adopters were still producing horticulture. Overall, the results suggest that there are different characteristics of adopting and non-adopting farmers with respect to cropping practices.

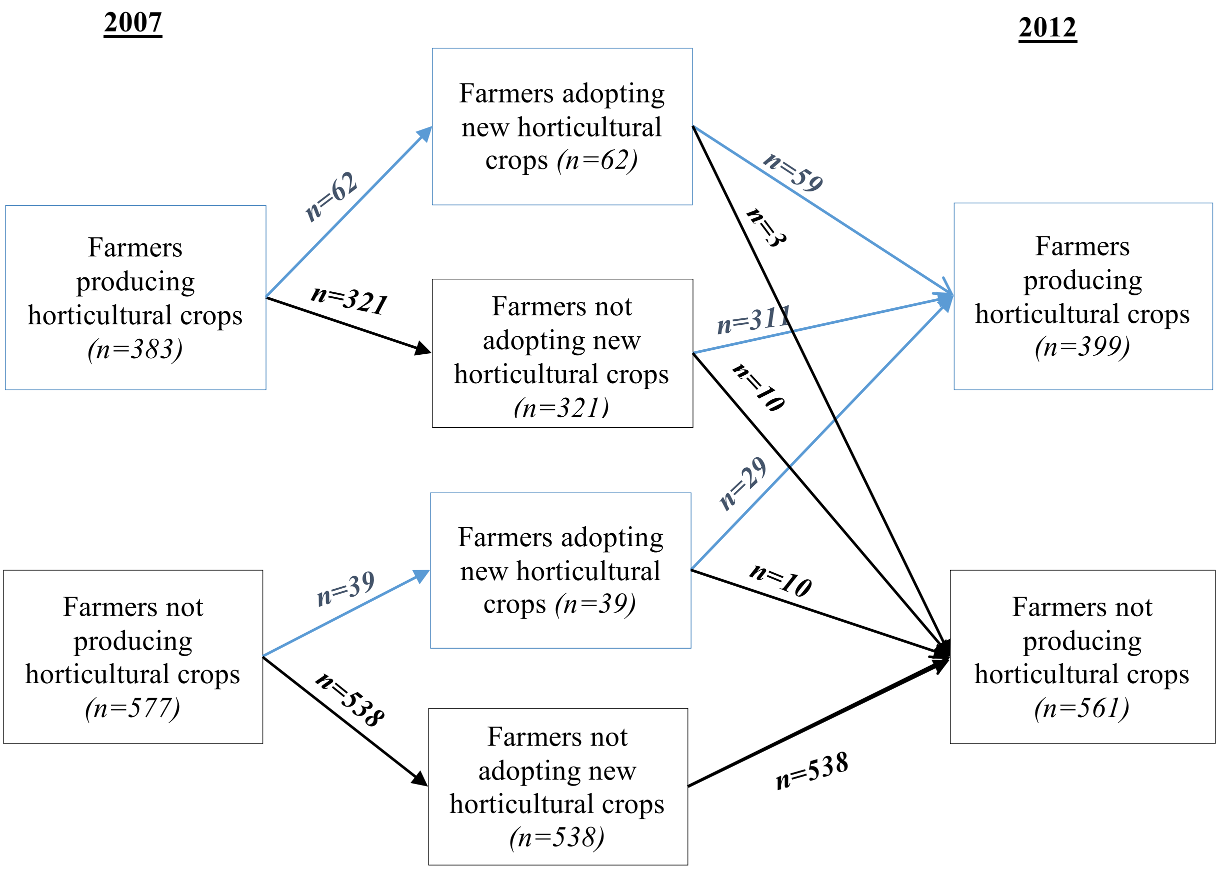


Figure 4.1. Dynamics of Indonesian farmer participation in horticultural crop production (2007-2012)

In terms of the number of crops adopted, most adopters adopted one new horticultural crop between 2007 and 2012 (Appendix 5). The main new vegetable crops adopted were chillies and shallots (Table 4.1). These two crops are an essential ingredient in Indonesian cuisine, and are consumed daily by the majority of Indonesian households.

In Indonesia, the production of shallots and chillies has been growing over the recent decades (BPS 2014). Consequently, many extension programs and incentive schemes are designed for these Indonesian priority crops, known as *komoditas unggulan,* to increase farmer adoption of these crops. Tomatoes, another important new vegetable crop adopted by Indonesian farmers, are also an example of the recent and rapid emergence of non-traditional crops in Indonesia (Hernández et al. 2015).

The main new fruit crops adopted were melon, watermelon and papaya (Table 4.1). This is in line with initial information gathered during interviews with extension officers that revealed that melon and watermelon were increasingly cultivated by farmers in areas such as Demak, Rembang and Jombang. In addition, many farmers have started to grow papaya, particularly new varieties, such as Calina (*IPB-9*), as demand for this fruit is growing. Another important new fruit crop adopted is mangosteen, which is another Indonesian priority commodity, mainly for export.

Table 4.1. Number of new horticultural crops adopted by adopting farmers (n = 101)

Vegetables		**Fruits**	
Crops	**Freq.**	**Crops**	**Freq.**
Chillies	18	Melon	9
Shallots	18	Watermelon	6
Cucumber	14	Papaya	5
String bean	9	Mangosteen	4
Eggplant	9	*Jambu air*	3
Tomatoes	5	Mango	1
Kangkung	5	Star fruit	1
Chinese cabbage	5	Snake fruit	1
Cabbage	4	*Lengkeng*	1
Spinach	4	*Matoa*	1
Green bean	3	Grape	1
Broccoli	3	*Blewah*	1
Gherkin	1		
Ginger	1		

Note: There were 28 of 101 adopting farmers that adopted more than one new horticultural crop.

4.3.1.2 Motivation of New Horticultural Crop Adoption

Farmers had various reasons for deciding to adopt new agricultural technology, including new horticultural crops. As discussed in Chapter 2, relative economic advantage, risk-reduction and input-minimisation of agricultural technology may be preferred by farmers when considering adoption of a new agricultural technology. These characteristics of agricultural technology include higher expected profit, more cash opportunities, stable yield and less labour used.

The main reasons Indonesian farmers adopt a new horticultural crop are shown in Figure 4.2. Results show that farmer motivations for adopting a new horticultural crop vary across farmers. The most important motivation for adoption of new horticultural crops is perceptions about the relative economic advantage, particularly potential to earn higher profit relative to other crops. This result is in line with previous studies that suggest relative profitability of horticultural crops, as compared to staple food crops, is associated with a higher level of diversification for horticultural crops (Joshi, Joshi & Birthal 2006; Minot & Roy 2007; Weinberger & Lumpkin 2007). Farmer preference for higher profit is reasonable as producing high value horticultural products, such as shallots and chillies, may make households more vulnerable to market risk associated with frequent price fluctuations. Indonesian farmers are also motivated by higher yield, more cash opportunities and growing demand for a horticultural crop. Thus, farmers seek to gain more benefits from the ongoing agri-food market transformation in Indonesia where demand for fruit and vegetables is increasing, as explained in Chapter 1.

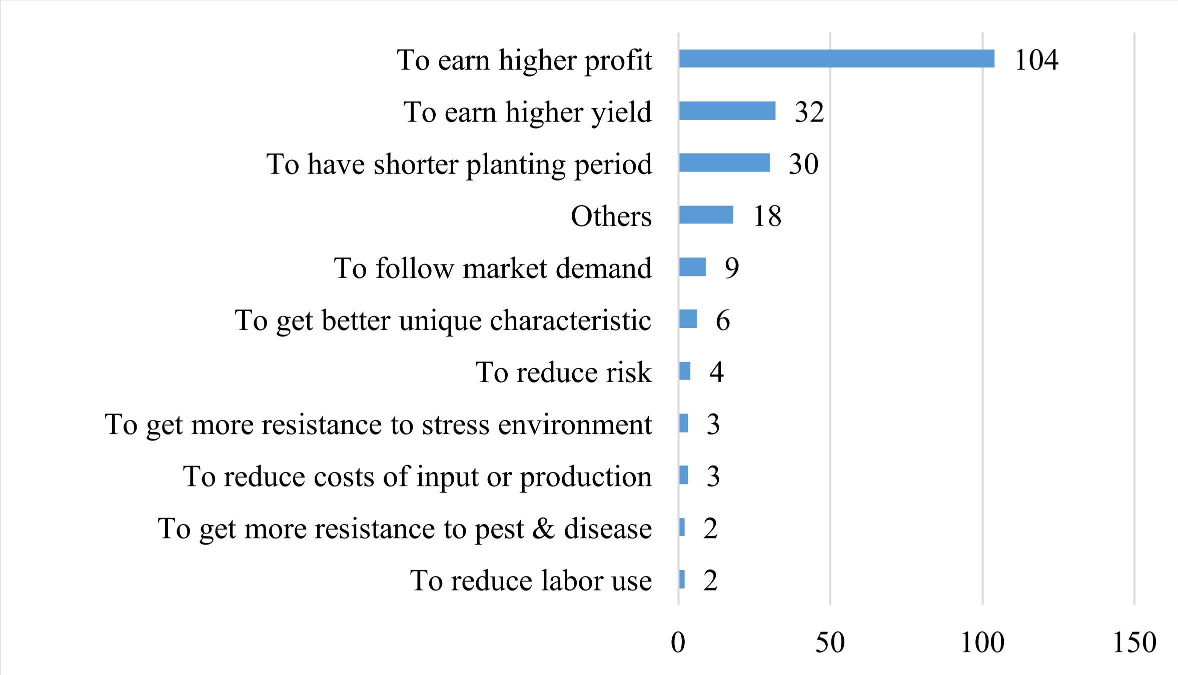


Figure 4.2. Main reasons motivating Indonesian farmers to adopt new horticultural crops (number of farmers' response, n = 101)[13]

4.3.1.3 Land Use Changes when Adopting New Horticultural Crops

As explained in Chapter 2, farm size is a major determinant influencing a farmers' decision to adopt new agricultural technologies (see Feder, Just & Zilberman 1985). Current national agricultural census data from Indonesia shows that 55.9% of farmers categorised as smallholder farms manage less than 0.5 ha of land (BPS 2013).

At the farm plot level, land use changes when adopting new horticultural crops are shown in Table 4.2. Results show that most land (40.6% of plots) was used for producing staple food crops, such as rice, maize and soybean, in the same season of the previous year. This suggests that a large share of adopting farmers are likely to have shifted focus away from staple foods to high value horticultural crops. According to national policy, however, three staple food crops (rice, maize and soybean) are the current national priority crops for

---

[13] This figure used respondents answers to the question "*What are the main reasons you decided to grow the [crop]?*" in the technology adoption module (see Section K in Appendix 15). Each respondent (adopter) can select maximum two answers. It is important to note that the respondent answered this question for each crop they adopted. There were 28 of 101 adopting farmers that adopted more than one new horticultural crop. From the 101 adopters, the total response was 243 answers.

food self-sufficiency in Indonesia. This indicates that new horticultural crop promotion programs include a trade-off between staple food versus horticultural produce. Chapter 7 addresses the loss of staple food supply caused by the expansion of horticultural production.

Table 4.2 shows that approximately 30% of farm plot use change involved shifting from one horticultural crop to another horticultural crop between 2007 and 2012. According to Reardon et al. (2015), shifting to higher value horticultural crops allows farmers to climb the value ladder. In addition, a shift in crop production earning higher value and more profitable crops is in line with Indonesian farmer motivations for new horticultural crop adoption, as explained above. Table 4.2 also shows that some farmers (roughly 10%) invested in additional land (buying or renting) to cultivate a new horticultural crop.

Table 4.2. Land use changes when adopting new horticultural crops at the farm plot level

Previous land use for	**Freq.***	**Percent**	**Current land use**
Horticultural crops	41	29.71	Melon, cucumber, shallots, papaya
Rice	31	22.46	Chillies, shallots, tomatoes, melon, watermelon
Secondary crops (e.g. maize, soybean)	25	18.12	Shallots, spinach, chillies, tomatoes, melon
Re-farmed	19	13.77	Chillies, mangosteen, shallots, watermelon, mango
New rent	11	7.97	Shallots, cucumber, chillies, watermelon
Other crops	8	5.80	Chillies, mangosteen, star fruit, *lengkeng*
New purchased	3	2.17	Chillies, shallots
Total	138	100	

Note: *Indicates the number of farm plots. The respondents (adopters) were asked indicate, for each crop they adopted, at their each farm plot. There were 28 of 101 adopting farmers that adopted more than one crop.

4.3.2 Characteristics of Adopters and Non-adopters of New Horticultural Crops

This section describes the types of Indonesian farmers adopting new horticultural crops. This study analysed the differences between adopters and non-adopters in terms of farmer and farm characteristics, institutional factors and sources of income. As mentioned earlier, the two-sample t-test was used to examine differences in mean values among adopters and non-adopters. These characteristics were expected to provide insight to why a specific farmer adopted new horticultural crops.

4.3.2.1 Household Characteristics

As explained in Chapter 2, household characteristics that are often determinants of agricultural technology adoption are human capital, assets and location. Table 4.3 presents these household characteristics and results of a difference test using the two-sample t-test on the variables.

Human capital

The average age of all respondents was 51 years (Table 4.3). This is parallel to the current national agricultural census (*Sensus Pertanian*) data, which shows that 28% of farmers are aged between 45 and 54, 26% (between 35-44), 20% (between 55-64), 13% (above 64), 12% (between 25-34) and 1% (below 25) (BPS 2013). On average, both adopting and non-adopting head of households completed primary school. All farm households in the two groups had a relatively similar number of household members aged between 15 and 65 years. The number of family members indicates availability of family labour that can be devoted to agricultural farming

The main significant differences in the two groups were that farm household heads of new horticultural crop adopters and their spouses had significantly higher education than non-adopters, horticultural crop adopting farmers were also significantly younger on average. Furthermore, most adopters were experienced horticultural farmers. This means that higher levels of education and practical horticultural farming experience can be considered important factors influencing adoption of high value horticultural crops. While most household heads were literate (could read and write), the spouses of adopters' had better literacy rates than non-adopters' spouses. This difference in literacy level may help improve spouses', who were in most cases women, understanding of new technologies including new horticultural crops.

Assets

Most farm households had access to regular electricity and water (Table 4.3). There were also similarities in terms of value of transportation and production assets between new horticultural crop adopters and non-adopters. The main difference was that most adopter households had access to a communication device or applications associated with information and communication technologies (ICTs), particularly mobile phone and Internet access. This suggests that ICTs may assist households to obtain access to information needed to produce new horticultural crops. Adopters also had higher value of storage assets for post-harvest activities of horticultural products, such as drying, sorting and grading.

Location

Both adopters and non-adopters of new horticultural crops had similar access to asphalt roads and local markets (Table 4.3). The main differences between the two groups were that most adopter households live in higher-level land areas (on average 293 metres) and were located further from urban markets (on average 23.35 km). This finding is in line with highland areas favouring horticultural crop production (Midmore & Poudel 1996; Poudel, Midmore & Hargrove 1998).

Table 4.3. Comparison of household (and farmer) characteristics for adopters and non-adopters of new horticultural crops

Household Characteristics	All Samples (n=960) Mean	Non-adopters (n=859) Mean	Adopters (n=101) Mean	Diff[1]
Human capital				
Age of household head (years)	51.69	52.10	48.26	3.84***
Education of household head (years)	7.21	7.10	8.12	-1.02***
Age of spouse (years)	42.05	42.17	41.04	1.13
Education of spouse (years)	6.59	6.48	7.56	-1.09***
% of HH can read	0.97	0.97	0.98	-0.01
% of spouse can read	0.89	0.89	0.96	-0.07**
% of HH can speak Bahasa	0.97	0.97	0.99	-0.02
% of spouse can speak Bahasa	0.89	0.88	0.96	-0.08**
Household size	3.78	3.75	4.09	-0.34**
Number of children aged under 15	0.69	0.65	1.06	-0.41***
Number of adults aged between 16 & 65	2.69	2.69	2.67	0.02
% of household engaged horticultural crops in 2007	0.40	0.37	0.61	-0.24***
Assets				
Area of house, including yard area (ha)	0.04	0.04	0.04	0.00
Value of house (million Rp)	134.28	134.81	129.77	5.05
% of household with own house	0.99	0.99	1.00	-0.01
% of household with electricity	1.00	1.00	1.00	0.00
% of household with own water source	0.81	0.81	0.80	0.00
% of household with own radio	0.42	0.42	0.44	-0.02
% of household with own television	0.94	0.94	0.97	-0.03
% of household with own computer	0.13	0.13	0.18	-0.05
% of household with own mobile phone	0.88	0.87	0.95	-0.08**
Owns mobile phone (unit)	1.83	1.79	2.24	-0.45***
% of household with owns internet access	0.29	0.27	0.45	-0.17***
Agricultural assets (million Rp)				
Transportation asset (e.g. motorbike)	8.42	8.61	6.81	1.79
Production asset (e.g. water pump, sprayer)	1.49	1.44	1.95	-0.51
Storage asset (e.g. storage house)	2.05	1.46	7.08	-5.62***
Owned land (ha)	0.56	0.57	0.49	0.08
Location				
Distance to nearest asphalt road (km)	0.19	0.20	0.16	0.03
Distance to nearest local market (km)	3.64	3.64	3.63	0.01
Distance to nearest urban market (km)	20.54	20.21	23.35	-3.14**
Elevation (m)	196.82	185.51	293.04	-107.5***

Notes: [1]Based on t-test: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

4.3.2.2 Farm Characteristics

This section focuses on farm characteristics in order to explore how adopters of new horticultural crops differ from non-adopters. Existing literature shows that farm characteristics, including farm size, land tenure, and cost of technologies, are important factors influencing agricultural technology adoption (Doss 2006; Feder, Just & Zilberman 1985; Rogers 2003). Table 4.4 shows a comparison of farm characteristics of adopters and non-adopters of new horticultural crops and highlight the practices of production, input use and harvesting.

Production characteristics

On average, for the entire sample, households farmed approximately 0.76 hectares, of which 0.52 hectares was owned farmed land (Table 4.4). The average farm size was not statistically different between adopters and non-adopters at 0.82 hectares and 0.76 hectares, respectively. Similarity of farm size suggests that most households in this study can be considered small-scale farmers, on average. Compared to current National Agricultural Census (*Sensus Pertanian 2013*) data, 45.4% of farm households in this study had less than 0.5 ha of land compared to the average for all Indonesian farmers (55.9%) (BPS 2013).

New horticultural crop adopters rented significantly more land than non-adopters. As described in Section 4.3.1.3, approximately 8.0% of the land used for planting new horticultural crops was rented land. In addition, in terms of diversification, farm household adopters were more diversified in the farming system. Adopters were also more diversified within horticultural crop production. This suggests that they tend to allocate land to different horticultural crops, presumably to meet continuous growing demand from markets for multiple horticultural products.

Another difference between adopters and non-adopters of new horticultural crops in Indonesia is that spouses of adopters in this study had less engagement with the household's horticultural crop production. This finding is contrast to recent studies, which highlight that women play a crucial role in horticultural development (e.g. Maertens & Swinnen 2012; Virchow et al. 2015). For example, Maertens and Swinnen (2012) found that women benefit more and more directly engage to labour market as hired employees in Senegalese horticultural chains. This finding also indicates that it is important to consider whether there is a need for specific horticultural production training programs for women in order to improve their skills. However, the study does not know whether women would want to participate in horticultural production training programs – they may well be choosing not to participate in this aspect of the household agricultural enterprise for reasons other than not having the relevant skills.

Production costs[14]

Table 4.4 shows production costs of farming activities. Total input costs were not significantly different between new horticultural crop adopters and non-adopters. However, the average total input costs of adopting farmers were relatively higher than non-adopting farmers, 8.78 versus 7.28 million Rupiah, respectively. Both new horticultural crop adopters and non-adopters spent relatively the same amount of money on chemical inputs, such as fertiliser and pesticide.

Adopters used more hired labour and spent more on purchasing seeds compared to non-adopters (Table 4.4). Another interesting difference was that new horticultural crop adopters spent slightly more on organic fertiliser and bio-pesticide. This is in line with initial information gathered from the scoping study interview that there were an increasing number of horticultural producers concerned about food safety and that there is growing market demand in Indonesia for horticultural products that are organic or grown using low input spray techniques (Minot et al. 2015; Wahida 2015).

---

[14] In this study, input costs included costs for inputs used to produce the household's three main crops, which ranged from horticulture and estate crops (e.g. sugarcane, tea) to rice, maize, soybean, and other staple crops.

Harvesting characteristics

On average, there were no significant differences in the total value of crops harvested and sold (or crop revenue) by households. However, the average value of crops produced per hectare was significantly higher for adopters of horticultural crops (Table 4.4). This is perhaps not surprising considering that value of horticultural crops per hectare is generally higher than staples, however, increased revenue may be offset by relatively higher costs of seed and fertiliser per hectare as discussed in the previous section paragraph.

In terms of trader-harvester contracts or *tebasan* systems[15], no statistically significant difference were found between adopters and non-adopters of new horticultural crops (Table 4.4). However, adopting farmers were more likely to enter into such a contract than non-adopting farmers as indicated by percentage of farm households with experiencing sold in *tebasan* system for horticultural products at 23 and 13%, respectively. Based on interviews with key informants in the study areas, farmers chose to enter trader-harvester contracts due to constraints regarding hired labour to complete harvest and conduct the post-harvest handling. Another reason for entering this contract is to receive payment from the buyer (trader) before harvest or upon delivery (Wahida 2015).

[15] *Tebasan* is defined as a contract harvesting system whereby crops are sold prior to harvest by the farmer to a middleman (trader), who employs contract workers to complete the harvest (see Manning 1988; Naylor 1992).

Table 4.4. Comparison of farm characteristics for adopters and non-adopters of new horticultural crops

Farm Characteristics	All Samples (n=960) Mean	Non-adopters (n=859) Mean	Adopters (n=101) Mean	Diff[1]
Production characteristics				
Owned-farmed land (ha)	0.52	0.52	0.45	0.08
Farmed land (ha)	0.76	0.76	0.82	-0.06
% of land that is rented	13.63	12.54	22.89	-10.3***
% of land that is irrigated	56.27	56.92	50.71	6.21
Gini index	0.13	0.12	0.18	-0.06***
Sympson diversification index	0.45	0.44	0.61	-0.17***
Number of crops planted	3.06	2.91	4.38	-1.47**
Number of horticultural crops planted	0.91	0.76	2.15	-1.39***
% of households where spouse managed at least one crop	0.28	0.28	0.25	0.03***
% of households having production contract with buyer	0.06	0.06	0.03	0.03
Production costs				
% of households using hired labor	0.86	0.85	0.94	-0.10***
Purchased seed costs (million Rp)	0.83	0.75	1.46	-0.70***
Organic fertilizer costs (million Rp)	0.27	0.26	0.28	-0.02***
Chemical fertilizer costs (million Rp)	1.94	1.90	2.27	-0.37
Other fertilizer costs (million Rp)	0.13	0.13	0.16	-0.03
Chemical pesticide costs (million Rp)	0.89	0.82	1.47	-0.65
Bio-pesticide costs (million Rp)	0.01	0.00	0.03	-0.02***
Tractor hire or animal costs (million Rp)	0.63	0.64	0.49	0.15***
Other crop input costs (million Rp)	2.76	2.78	2.62	0.16
Total input costs (million Rp)	7.44	7.28	8.78	-1.50
Harvesting characteristics				
Harvest value (revenue in million Rp)	32.13	31.96	33.57	-1.61
Harvest value (revenue) per hectare	46.50	45.63	53.92	-8.29*
Harvest value (revenue) from horticultural crops (million Rp)	4.90	3.94	13.11	-9.17***
Harvest value (revenue) from horticulture per hectare	16.35	14.01	24.53	-10.52***
Harvest value (revenue) from staple food crops (million Rp)	22.14	22.66	17.66	5.01
% sold value from horticultural crops	18.55	15.45	44.25	-28.80**
% sold value from staple food crops	64.59	67.43	41.00	26.43***
% of households selling crop “in ground”	0.44	0.44	0.47	-0.02***
% of household selling using *tebasan* systems for horticultural crops	0.14	0.13	0.23	-0.10

Note: [1]Based on t-test: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

4.3.2.3 Institutional Factors

As described in Chapter 2, institutional factors, such as producer organisation involvement and access to information were considered important variables that may increase rates of adoption. Table 4.5 presents a comparison of institutional factors.

Table 4.5. Comparison of institutional characteristics and income sources for adopters and non-adopters of new horticultural crops

Characteristics	All Samples (n=960) Mean	Non-adopters (n=859) Mean	Adopters (n=101) Mean	Diff[1]
Institutional characteristics				
Received information about horticultural production from extension officers (1/0)	0.19	0.16	0.43	-0.27
Received information about staple production from extension officers (1/0)	0.55	0.54	0.67	-0.14***
Participated in FFS GAP/GHP[16] for horticultural crops (1/0)[a]	0.09	0.08	0.16	-0.08
Participated in FFS ICM for staple food crops (1/0)[b]	0.36	0.35	0.44	-0.09**
Participated in FFS IPM (1/0)[c]	0.42	0.41	0.53	-0.13*
Membership in farmer group/cooperative (1/0)	0.78	0.77	0.89	-0.12***
Membership in water use association (1/0)	0.32	0.32	0.30	0.02
Membership in women farmer's group (1/0)	0.04	0.04	0.10	-0.06
Membership in *gotong royong* (1 if yes, 0 otherwise)	0.11	0.11	0.14	-0.03

Note: [1]Based on t-test: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. [a] Farmer Field School-Good Agricultural Practices/Good Handling Practices, [b]Farmer Field School-Integrated Crop Management, [c]Farmer Field School-Integrated Pesticide Management

New horticultural crop adopters had a significantly higher rate of participation in extension programs, such as horticultural production and farmer field of school of good agricultural practices (FFS GAP) for horticultural crop training programs, as compared to

[16] The training programs provide information for addressing environmental, economic and social sustainability for on-farm production and post-production processing. These include technical assistance and training to support farmers in implementing GAP/GHP at the farm-level (e.g. on aspects such as pesticide application, production processes, and post-harvest handling).

non-adopters. The training programs include assistance on how to produce fruits or vegetables in order to meet food safety standards. This suggests that a lack of information and knowledge about horticultural farming practices could be an obstacle to the adoption of horticultural crops. Furthermore, a significantly higher proportion of adopters were involved in farmer groups or cooperatives. This involvement perhaps offers opportunities for training programs including training related to horticultural crop production. In addition, previous studies show that involvement in producer groups could influence farmers to adopt a new agricultural technology (Abebaw & Haile 2013; Matuschke & Qaim 2009).

4.3.2.4 Income Activities[17]

This section provides details on the household income characteristics of adopters and non-adopters of new horticultural crops. It is important to explore the contribution of each source of income in order to consider possible economic benefits of agricultural technology adoption. Table 4.6 presents a comparison of income sources of adopters and non-adopters, including farm and non-farm activities. In this study, farm activities include income from growing agricultural crops (horticulture, estate and other staple food crops), livestock activities, and aquaculture activities. Non-farm activities include all other activities which garner household income, as shown in Table 4.6.

For both adopters and non-adopters, the main source of income for both groups was from agricultural activities. No statistically significant differences were found between the net household incomes new horticultural crop adopters and non-adopters (Table 4.6). The share of total net household income from agriculture was similar for both groups. The only significant difference was that recent horticultural adopters had a higher net income from horticulture crops.

[17] In this study, the calculation of agricultural income includes imputed income from agriculture.

Both adopters and non-adopters of new horticultural crops also generate income from non-farm activities: trading and enterprises, agricultural wage labour, non-agricultural employment, pension, remittances from family members, assistance programs, and other sources of income (Table 4.6). Overall, the average household income from these activities was not statistically different across the two groups. Interestingly, no farm households in this study indicated that they received assistance from programs, such as subsidies from the Indonesian government or other non-governmental and civil society organisations.

Table 4.6. Comparison of income sources for adopters and non-adopters of new horticultural crops

Income sources (Rp million)	**All Samples (n=960) Mean**	**Non-adopters (n=859) Mean**	**Adopters (n=101) Mean**	**Diff[1]**
Net household income	42.39	42.72	39.55	3.18
Net household income, excluding imputed income	35.27	35.55	32.89	2.65
Net household income per capita	11.99	12.20	10.18	2.02
Net income from agriculture	21.99	22.04	21.52	0.53
Net income from agriculture, excluding imputed income	14.86	14.87	14.86	0.00
% of net household income from agriculture	57.01	57.16	55.73	1.43
Net income from horticulture	2.65	2.18	6.69	-4.51***
Net income from staple food crops	13.32	13.65	10.49	3.16
Net income from other crops (e.g. sugarcane)	3.14	3.27	2.04	1.23
Net income from livestock and aquaculture	2.86	2.92	2.30	0.62
Gross income from non-horticulture	26.05	27.04	17.65	9.40***
Net income from remittance	1.35	1.44	0.59	0.86
Net income from agricultural wage	0.89	0.84	1.34	-0.50
Net income from non-agricultural wage	6.48	6.64	5.09	1.55
Net income from trading and enterprises	9.67	9.63	10.04	-0.42
Net income from assistance programs	0.00	0.00	0.00	0.00

Note: [1]Based on t-test: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

4.4 Summary and Conclusions

This study identified relatively low adoption rates (10%) of new horticultural crops amongst the 960 selected farm households from six districts across Java Island. Among adopters of new horticultural crops, different decisions were made in terms of number and time to adopt new horticultural crops. Adopters were motivated mainly by higher profit, higher yield and the perception that there were more cash opportunities resulting from growing higher value horticultural crops.

In relation to the relatively low adoption rate of horticultural crops, results of basic descriptive statistical analysis suggest that existing household-level characteristics may be constraining factors for farmers to adopt new horticultural crops. Non-adopters are relatively older, less educated, and less diversified in their farming systems. They are also less likely to own mobile phones and to have Internet access. In general, they also lack information and training with regards to horticultural crop production methods. In addition, results show that many non-adopters were not participating in producer organisations, such as a farmer group or cooperatives – in Indonesia, these types of organisations are often used to disseminate information about new technologies as well as the technology, including seeds.

Study findings suggest that recent adopters of horticultural crops have some significantly different characteristics as discussed in this chapter. The following chapters of this thesis, Chapters 5 and 6, elaborate on farmer perceptions of technology attribute, which in this case the technology being considered is a new crop. The determinants of horticultural crop adoption among farmers in Indonesia are also explored using rigorous analysis.

This chapter also shows that new horticultural crop adoption includes both a shift from one horticultural crop to another and from staple crops to horticultural crops. This suggests that some Indonesian farmers have likely already shifted their focus away from staple crops to higher value horticultural crops. This means that there is a potential loss of staple food supply caused by expansion of horticultural production. Another finding of this study revealed significant difference between adopters and non-adopters in terms of non-horticultural income. In relation to this finding, Chapter 7 explores the trade-offs between horticultural crop diversification and staple food supply and income.

5 Chapter Five: Farmer Preferences for Technology Attributes: An Application of Best-Worst Scaling[18]

5.1 Introduction

As described in the literature review presented in Chapter 2, perceptions of technology attributes are considered to be some of the most important factors in understanding the adoption decision. However, few studies have addressed perceptions of technology attributes in the context of adoption of agricultural technology by smallholder farmers (e.g. Adesina & Zinnah 1993; Batz, Peters & Janssen 1999; Hintze, Renkow & Sain 2003; Lunduka, Fisher & Snapp 2012). In the Indonesian context, a recent study by Wahida (2015) showed that farmer preferences for technology attributes are heterogeneous at the individual and cluster or segment levels. However, the study by Wahida was based on a specific group of Indonesian farmers, in this case shallot farmers. This study adds to the literature by examining Indonesian farmers at a larger more general level including the farmers who adopt any new horticultural crops.

To address the knowledge gap, this chapter addresses two specific research questions forming the second objective of this thesis. The first research question is "Which crop attributes do Indonesian farmers prefer when they are considering the adoption of a new crop?" This question regarding which attributes of crops are most important to farmers arises naturally, as crops are clearly differentiated by their attributes. For example, some crops offer an expected high profit relative to other crops, while some require fewer inputs (e.g. pesticides). According to Joshi, Joshi and Birthal (2006) and Virchow et al.

[18] The initial draft of Chapters 5 and 6 were combined into a manuscript paper and presented at four international conferences: (1) the 58th Annual Conference of the Australian Agricultural and Resource Economics Society (AARES), 4-7 February 2014 in Port Macquarie, NSW, Australia; (2) the 2nd Global Food Symposium, 25-26 April 2014 in Gotttingen, Germany; (3) the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting, 26-28 July 2015 in San Francisco, CA and (4) 29th International Conference on Agricultural Economists (ICAE), 8-14 August 2015 in Milan, Italy. The paper was also accepted at the 12th Wageningen International Conference on Chain and Network Management (WICANEM), 4-6 June 2014 in Capri Island, Italy, but I withdrew from participation.

(2015), relative to rice and other staple food crops, high value crops like vegetables are more labour intensive in activities such as planting, harvesting and post-harvest handling. In addition, choices regarding crop attributes vary amongst farmers. It is commonly understood that farmers prefer more profitable crops. However, there are other crop attributes that farmers may see as constraints, such as labour, water, start-up costs, and training and assistance on how to produce certain crops. Hence, farmers may consider these to be important crop attributes when considering whether or not they will adopt a new crop. While some previous studies have used the price of labour or water pump ownership to model the trade-offs between agricultural technologies, this study uses the attributes themselves directly in the model.

The second research question of this study is "Does heterogeneity exist in Indonesian farmer preferences for crop attributes?" This question arises as accounting for heterogeneity enables the estimation of more consistent parameters of preference clusters. Understanding heterogeneity and being able to identify unique clusters or segments of farmers and their specific preferences and needs will be helpful information when designing programs and policies to help encourage and improve adoption rates. Results of recent studies on farmer preferences confirm that heterogeneities exist amongst farmers (Sahara, Umberger & Stringer 2013; Umberger et al. 2015; Wahida 2015; Wolf & Tonsor 2013). In addition, these studies suggest that there are unique groups (segments) of farmers with similar preferences for certain attributes.

This study contributes to existing literature by presenting an analysis of data from the Indonesian farmer survey discussed in previous chapters, which employs a unique best-worst (BW) scaling task. This application of BW scaling examines the relative importance that farmers place on various crop attributes when making the decision to adopt a new crop. This knowledge will help policy makers to set development program priorities by addressing specific attribute preferences. Therefore, this will improve the acceptance of new crops by farmers. This study also presents a non-traditional cluster analysis to examine whether farmers can be classified into groups or segments based on perceptions of their preferred crop attributes. In addition, the cluster analysis allows for the identification of groups or segments of farmers that share similar preferences. Identifying groups of Indonesian farmers with similar preferences for crop attributes is important to help policy makers to develop targeted programs which address the different needs of groups of farmers.

The remainder of this chapter is structured as follows: Section 5.2 provides an overview of data and methods including the BW scaling experiment and LC cluster analysis; this is followed by the estimated results and discussion of results in Section 5.3. The summary and conclusion are presented in the final section.

5.2 Data and Methods

5.2.1 Data from the Indonesian Farmer Survey

As discussed in Chapter 3, this study analysed primary data obtained during 2012-2013 from a survey of Indonesian farmers that grow a variety of agricultural crops in both high elevation and lowland areas. A stratified random sample of 960 farmers was drawn from 96 villages across Java. The random sample included a significant amount of variation in production technologies employed by farm households. In addition to collecting information on farming systems and household characteristics, the survey included a BW scaling task (see Finn & Louviere 1992) that revealed farmer preferences for crop attributes.

Data analysis was carried out in two steps. First, data gathered through the BW scaling task was analysed using Excel and SPSS software to determine relative importance of 11 crop attributes and to obtain individual farmer scores for each BW attribute. Second, a latent class (LC) cluster analysis was conducted using LatentGold 4.5 software to model the heterogeneity of farmer preferences. Detailed information regarding the methods is presented in the next section.

5.2.2 Best-Worst Scaling

This section explains the BW scaling experiment used to determine heterogeneity in farmer preferences for crop attributes. This scaling method is based on random utility theory for paired comparisons (see Finn & Louviere 1992). The BW scaling, originally devised by Finn and Louviere (1992), has been commonly applied in consumer studies to determine the relative importance of health care and food product attributes and personal values (e.g. Auger, Devinney & Louviere 2007; Cohen 2009; Finn & Louviere 1992; Flynn et al. 2007; Lagerkvist, Okello & Karanja 2012; Louviere et al. 2013; Mueller & Rungie 2009). However, the literature related to producer preferences using BW scaling is limited. A few recent studies have used BW scaling to analyse farmer preferences for market channel attributes (Sahara, Umberger & Stringer 2013; Umberger et al. 2015), policy options (Wolf & Tonsor 2013) and crop and farming system attributes (Wahida 2015).

BW scaling may be preferred to other traditional ranking and rating methods, due to four potential benefits. Firstly, as already explained in Chapter 2, BW scaling is a relatively simple method of measuring relative importance of attributes (Balcombe, Rigby & Azapagic 2014; Cohen & Orme 2004) as it requires respondents to make trade-offs among relatively smaller sub-sets of attributes. In other words, BW scaling requires respondents to rank attributes for the best and worst attributes only, rather than ranking all attributes. In addition, choosing both the best (most important) and worst (least important) attributes, particularly when comparing many attributes, is universally understood (Auger, Devinney & Louviere 2007; Mueller & Rungie 2009). Secondly, BW scaling can avoid median of responses which often occurs from ranking and rating methods (Balcombe, Rigby & Azapagic 2014; Cohen & Orme 2004). Thirdly, BW scaling avoids scale bias or differences in response to commonly used labels in rating scales such as 'very' and 'quite'. Fourthly, BW scaling provides considerably more information about individuals' preferences than traditional best choice experiments (Vermeulen, Goos & Vandebroek 2010).

To apply the BW scaling experiment, respondents were presented with sets of crop attributes. Crop attributes included in the BW scaling task were developed based on a review of previous studies in innovation attributes (e.g. Fliegel & Kivlin 1966; Rogers 2003), crop variety preferences (e.g. Batz, Peters & Janssen 1999; Edmeades et al. 2008; Hintze, Renkow & Sain 2003; Wale & Yalew 2007) and crop and farming system preferences (Wahida 2015), as well as extensive interviews with farmers, farmer group leaders and extension officers. Originally 26 attributes were chosen and were then pre-tested with more than 30 farmers during the sample development process and again during the enumerator training sessions. The attributes were modified slightly after receiving feedback during pre-testing. This process resulted in a final set of 11 technology (crop) attributes being chosen. Each attribute is listed and defined in Table 5.1.

Table 5.1. Crop attributes and descriptions used in the BW questionnaire

Attributes	Descriptions of Attributes
Higher expected profit	New crops are expected to generate higher profit or return relative to other crops
Stable price	Price for new crops is expected to be more stable and consistent and less risky with fewer fluctuations and with a guaranteed market
Stable yield	New crops are expected to produce stable and consistent yield or less variable yield (e.g. new crop is resistant to weather, pests and disease)
Seed access	Good quality seeds of new crops are accessible
Less labour	Less labour is required to produce new crops
Less water	New crops require use of less water than other crops
Low start-up cost	Shifting to new crops needs low initial investment / start-up costs
Success of neighbours	Other farmers or neighbours have adopted new crops and have been successful
Subsidies provided	Government should provide subsidies or incentives to plant new crops
Cash opportunities	New crops provide cash opportunities when needed (e.g. flexible harvest)
Training provided	Training and assistance on how to produce new crops is accessible (easy to reach and affordable)

The 11 attributes represented a wide range of categories of technology attributes that drives adoption. These attributes include relative economic advantage (e.g. high expected profit), cost (e.g. low initial investment costs, less labour required), trialability (e.g. success of neighbours) and risk or uncertainty (e.g. stable and consistent yield, stable and consistent price). Attributes such as yield, water and labour requirement are production-related attributes, while price is a market-related attribute.

A balanced incomplete block design (BIBD) (see Finn & Louviere 1992; Louviere, Flynn & Marley 2015) was used to develop 11 choice sets or ‘tasks’ with five attributes each. This design ensured that each attribute appeared five times across the 11 choice tasks. Respondents were asked to complete the 11 choice tasks. For each choice task, they simultaneously chose which one of the five attributes was ‘most important’ (‘best’) and another that was ‘least important’ (‘worst’). During interviews with respondents, each choice task was presented on a separate card. An example of one of the 11 BW scaling tasks[19] is presented in Figure 5.1.

For the following question, please tick one box in the left column to indicate the attribute that is MOST important to you and please tick one box in the right column to indicate the attribute that is LEAST important to you when considering whether to adopt a new crop. Please tick only one box per column.

Most Important (tick one box)	Of the following, which attributes are the Most and Least important to you…	Least important (tick one box)
○	1. High expected profit / return relative to other crops	○
○	4. Good quality seeds are accessible	○
○	5. Less labour is required	○
○	9. Government provide subsidies or incentives to plant	○
○	3. Stable and consistent yield (e.g. crop is resistant to weather, pests and disease)	○

Figure 5.1. Example of a BW scaling task

To analyse BW data, a counting method approach was applied consisting of calculating BW scores (frequencies), standardised scales, means and variances. The counting method was applied to the individual respondent and aggregated at the sample level (Mueller & Lockshin 2013).

To obtain individual BW scores for each of the 11 crop attributes, the number of times each farmer (*i*) indicated an attribute (*j*) was 'most' (B_{ij}) and 'least' (W_{ij}) important was calculated. The sum of the 'least' in each attribute was subtracted from the sum of the 'most' (B_{ij}-W_{ij}). Next, respondent choices for 'most' and 'least' important attributes were compiled and calculated to create two aggregate frequency values for each attribute: 'most' and 'least'. Aggregate frequency values are the number of times each attribute was chosen as most important and least important.

[19] It is important to note that the BW scaling task in this study is the case 1 of the three cases of BW scaling (see Louviere, Flynn & Marley 2015).

To determine the relative importance of these attributes, a ratio-based scale was developed by taking the square root of 'most' frequency divided by the 'least' frequency value for each attribute: Sqrt(B/W). Next, this Sqrt(B/W) was transformed to a 0 to 100 scale for all attributes. According to Mueller and Rungie (2009), this standardised interval scale makes aggregate BW results easier to be interpreted. The attribute with the highest Sqrt(B/W) received a score of 100 (most important) and other attributes were scaled relative to this attribute.

The mean and standard deviation (variance) values from individual BW scores were also calculated. Thereby, both values were derived from aggregated choices of best and worst over every respondent and crop attribute. According to Mueller and Rungie (2009), the mean of individual BW score can be used to determine attribute importance of all attributes. The reason is that it is most closely related to the variance-covariance matrix. On the other hand, standard deviation of individual BW score indicates the heterogeneity (variance) of crop attribute importance. A higher standard deviation indicates wider variety of relative importance for a given crop attribute. Conversely, a smaller standard deviation is indicative of general agreements between farmers on the relative importance of a given crop attribute. However, the standard deviation only conveys information regarding heterogeneity that may be present across farmers. Therefore, this study further analysed individual BW scores to model preference clusters to better qualify distinct farmer segments based on preferences for crop attributes. The next section presents a detailed explanation of grouping farmers by homogeneous preferences for crop attributes using cluster analysis.

5.2.3 Modelling Heterogeneity in Preferences for Crop Attributes

Based on individual scores for each BW scaling attribute, a non-traditional cluster analysis, a latent class (LC) cluster was employed. Cluster analysis was conducted using

LatentGold 4.5 software to model heterogeneity of farmer preferences. This study expected the heterogeneity in farmer preferences for crop attributes. This hypothesis is based on the diversity of farmer preferences and similarly to previous studies, applied LC cluster analysis to farmer choices (Sahara, Umberger & Stringer 2013; Umberger et al. 2015; Wahida 2015; Wolf & Tonsor 2013).

LC clustering is defined as the classification of individuals or objects into a predetermined number of latent clusters. Therefore, this clustering technique assumes that the population consists of a certain number of latent clusters with different utility functions (Boxall & Adamowicz 2002). This classification is also analysed without prior information about the forms or parameters of a cluster, such as mean, variance and covariance (Rousseeuw & Kaufman 1990). Cluster parameters are relatively homogenous within clusters, but differ between the clusters.

The LC cluster model is preferred to standard cluster analysis techniques (e.g. K-means, hierarchical) because this technique is a model-based clustering approach (Vermunt & Magidson 2002). In this technique, individuals in the same class are assumed to have similar probability distributions. This technique also includes minimising variance within cluster and maximising variance across cluster. In addition, the LC cluster concurrently estimates choice probability and cluster membership (Boxall & Adamowicz 2002; Vermunt & Magidson 2002).

To predict cluster membership in this study, active covariates were not included in the LC cluster model specification. This differs to previous studies (e.g. Sahara, Umberger & Stringer 2013; Umberger et al. 2015; Wahida 2015; Wolf & Tonsor 2013) that include active covariates. For example, Wahida (2015) included active covariates by controlling for other variables that may also help to explain adoption decisions, such as education and experience. This study only utilised the 960 individual BW scores (B_{ij}-W_{ij}) for 11 crop attributes as indicator variables to estimate cluster membership. It was important to estimate a number of unique preference clusters based only on farmer preferences for crop attributes. Thus, preference clusters are included as a factor influencing horticultural crop adoption in Chapter 6.

There are no formal statistical criteria to determine the optimal number of clusters. However, a number of authors (e.g. Boxall & Adamowicz 2002; Vermunt & Magidson 2002) have suggested the use of information theoretic criteria tempered by the analyst's own judgment as a model selection tool. Similar to many previous studies, this study used Bayesian Information Criteria (BIC). This statistical criteria was weight fitted by adjusting the log-likelihood (LL) to account for a number of parameters in the model (for more details, see Vermunt & Magidson, 2002). When comparing models, the smallest value of BIC indicates the best fit of the model to data (Vermunt & Magidson 2002). Using that information as part of the results of LC cluster analysis, an optimal number of unique clusters of farmers was established based on preferences for crop attributes.

This study expanded upon LC cluster analysis ex-post to further explain clusters in regards to farmer crop preferences, socio-demographic characteristics and adoption behaviour. A post-hoc Tukey Honestly Significant Difference (HSD) test was used to determine significant differences in crop preferences, socio-demographic characteristics and adoption behaviour across four clusters (Abdi & Williams 2010).

5.3 Results and Discussion

5.3.1 Crop Attribute Importance

The aggregate BW results are presented in Table 5.2. Results revealed that when aggregated, all importance measures, aggregated (BW), mean (BW) and standardised Sqrt (B/W), result in a consistent ranking of attributes. The attribute *higher expected profit* was most often chosen (2003 times out of 10,560 times or 19%[20]) as most important (best) and least often chosen (316 times out of 10,560 times or 3%[21]) as least important (worst) by farmers. Therefore, this attribute had the highest aggregated best-worst score (1687). The mean of individual BW score (1.76 out of 5[22]) represents the average BW per farmer and is derived by dividing the aggregated BW score by sample size (960).

When standardised to the ratio scale, Sqrt (B/W), results suggested that the most important attribute preferred by farmers when making the decision to adopt a new crop is *higher expected profit or return* (standardised to 100%) (Table 5.2). This result is in line with results of descriptive analysis of farmer reasons for adopting horticultural crops discussed in Chapter 4 and the previous study by Wahida (2015). The attribute *stable and consistent yield* (scaled at 64%) and *good quality seeds* (scaled at 62%) may also be considered very important attributes to Indonesian farmers, however, they are 36% and 38%, respectively, less important than *higher expected profit,* on average. Another interesting result is that the attributes *government subsidies or incentives to plant* and *training and assistance on how to produce* are approximately half as important as the attribute *higher expected profit*.

When making crop adoption decisions, the attributes *less labour* (approximately 17% relative importance) and *less water* (approximately 12% relative importance) were the least important attributes for this sample of Indonesian farmers (Table 5.2). This was contrary to initial information gathered through interviews with extension professionals when the BW scaling task and questionnaire were being developed. Extension professionals indicated that farmers were experiencing issues of labour and water scarcity. This suggests that some farmers may have been experiencing problems with access to

[20] The sum of best scores is 10,560 in Table 5.2.
[21] The sum of worst scores is 10,560 in Table 5.2.
[22] It is important to note that in this study every attribute appeared five times in the choice design. In addition, all participants completed every choice task. Therefore, the maximum number it could be chosen as most (best) and least (worst) important was 5 times.

labour and water, however, when forced to make a trade-off among other attributes (e.g. *higher expected profit, stable yield,* and *seed access)*, they placed the attributes *less labour* and *less water* as relatively less important.

In terms of degree of heterogeneity in the importance of crop attributes amongst farmers, all attributes have a standard deviation above one (Table 5.2). This indicates that all attributes have high heterogeneity in importance across farmers. Attributes of *training provided, success of neighbours* and *stable price* had a higher standard deviation showing relatively higher farmer disagreement on relative importance. In contrast, lower standard deviation of the attributes *seed access, stable yield, low start-up cost* and *less labour* indicated farmer agreement on relative importance.

Table 5.2. Relative importance of the 11 crop attributes by BW scaling

Attribute	**Best**	**Worst**	**Aggregated B-W**	**Mean B-W**	**Std. Dev B-W**	**SQRT (B/W)**	**Sqrt stand.**	**Rank**
Higher expected profit	2003	316	1687	1.76	1.81	2.52	100.00	1
Stable yield	1255	485	770	0.80	1.73	1.61	63.89	2
Seed access	1073	444	629	0.66	1.57	1.55	61.75	3
Subsidies provided	1183	554	629	0.66	1.81	1.46	58.04	4
Stable price	1266	648	618	0.64	1.94	1.40	55.52	5
Training provided	1308	680	628	0.65	2.05	1.39	55.09	6
Cash opportunities	873	882	-9	-0.01	1.84	0.99	39.52	7
Low start-up cost	589	1296	-707	-0.74	1.74	0.67	26.78	8
Success of neighbour	484	1448	-964	-1.00	1.97	0.58	22.96	9
Less labour	330	1749	-1419	-1.48	1.79	0.43	17.25	10
Less water	196	2058	-1862	-1.94	1.88	0.31	12.26	11

Overall, results suggest that individual farmers have heterogeneous preferences for crop attributes. In other words, individual farmers do not value all crop attributes equally. Analysis of the variance of individual BW scores can distinguish crop attributes of similar importance to all respondents (low variance) from those which vary in importance between farmers (high variance). Therefore, the next section presents an expanded analysis to further explore heterogeneity across groups of farmers with more homogenous preferences.

5.3.2 Farmer Heterogeneity for Crop Preferences

Results of the BW scaling task presented above indicate the relative importance to farmers of different crop attributes choosing a new crop at an aggregate level. The second objective of this chapter is to examine whether farmers are heterogeneous in their preference for crop attributes and to characterise those who are more or less likely to prefer certain crop attributes.

Results of LC cluster analysis indicated that the four-cluster model with 11 BW indicators is the model with the best fit (Table 5.3). The four-cluster model produced the smallest BIC value and best Wald test (F-value was 11.15, and it was highly significant at the five per cent level of significance).

Table 5.3. Summary of LC cluster analysis

	Cluster number	**LL**	**BIC(LL)**	**Npar**	**Classification error**
Model1	1-Cluster	-21120.10	42954.36	104	0.000
Model2	2-Cluster	-20972.57	42741.70	116	0.121
Model3	3-Cluster	-20863.99	42606.96	128	0.179
Model4	4-Cluster	-20810.82	42583.00	140	0.236
Model5	5-Cluster	-20772.40	42588.58	152	0.243

Note: LL = Log-likelihood; BIC = Bayesian information criterion; Npar = Number of parameters

Maximum likelihood parameter estimates of the four-cluster model are presented in Table 5.4. Results show that all crop attributes were significant in determining the number of clusters generated from LC cluster analysis. Moreover, results also show that differences in preferences for crop attributes across clusters exist as indicated by differences in the magnitude and signs of parameter estimates.

Table 5.4. Maximum likelihood parameter estimates of the four-cluster model

	Cluster1	**Cluster2**	**Cluster3**	**Cluster4**	**F value**	**R^2**
Higher expected profit	-0.09	0.52	-0.22	-0.21	31.38***	0.19
Stable price	-0.09	0.23	0.37	-0.51	42.98***	0.22
Stable yield	-0.11	0.37	0.49	-0.75	48.83***	0.28
Seed access	0.12	-0.18	0.02	0.04	7.79**	0.03
Less labour	-0.40	-0.40	0.24	0.57	67.84***	0.27
Less water	-0.24	-0.35	0.32	0.26	46.41***	0.20
Low start-up cost	-0.43	-0.05	0.14	0.35	53.52***	0.17
Success of neighbours	0.02	0.11	-0.33	0.20	20.84***	0.10
Subsidies provided	0.40	0.00	-0.40	-0.01	49.31***	0.18
Cash opportunities	0.15	-0.05	-0.23	0.13	26.07***	0.06
Training provided	0.48	-0.15	-0.16	-0.17	26.55***	0.23

Notes: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Further detailed explanations of the relative importance of attributes for each cluster using post hoc characterisation is discussed in Section 5.3.2.1. The unique characteristics based on a comparison of means of socio-economic, farm and farmer characteristics and adoption behaviour across clusters are explained in Sections 5.3.2.2 and 5.3.2.3, respectively.

5.3.2.1 Relative Importance of Crop Attributes Across Four Farmer Clusters

Mean BW scores for each crop attribute indicate the relative importance of crop attributes across four latent clusters (Table 5.5). The dimension of attribute importance is shown in Figure 5.2. Overall, results were consistent with the results of magnitude and signs of parameter estimates in Table 5.4, above. Responses reported in Table 5.4 and Table 5.5 indicate that Indonesian farmers do not have homogenous preferences for crop attributes across the four clusters.

Table 5.5. Mean BW indicators for each crop attribute by LC cluster

	Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**
Cluster Size	33%	29%	20%	18%
Crop Attribute	**Mean B-W**	**Mean B-W**	**Mean B-W**	**Mean B-W**
Higher expected profit	$1.36^{a,b}$	$3.21^{a,c,d}$	$0.94^{b,c}$	1.04^{d}
Stable price	$0.24^{a,b,c}$	$1.34^{a,d,e}$	$1.80^{b,d,f}$	$-1.09^{c,e,f}$
Stable yield	$0.40^{a,b,c}$	$1.59^{a,d,e}$	$1.86^{b,e}$	$-0.96^{c,d,e}$
Seed access	0.97^{a}	$0.17^{a,b,c}$	0.75^{b}	0.76^{c}
Less labour	$-2.26^{a,b}$	$-2.23^{c,d}$	$-0.55^{a,c,e}$	$0.20^{b,d,e}$
Less water	$-2.46^{a,b}$	$-2.85^{c,d}$	$-0.63^{a,c}$	$-0.93^{b,d}$
Low start-up cost	$-1.70^{a,b,c}$	$-0.71^{a,d,e}$	$-0.24^{b,d,f}$	$0.48^{c,e,f}$
Success of neighbour	$-0.98^{a,b}$	-0.58^{c}	$-2.33^{a,c,d}$	$-0.23^{b,d}$
Subsidies provided	$1.67^{a,b,c}$	$0.52^{a,d}$	$-0.68^{b,d,e}$	$0.50^{c,e}$
Cash opportunities	$0.50^{a,b}$	$-0.27^{a,c,d}$	$-0.86^{b,c,e}$	$0.43^{d,e}$
Training provided	$2.26^{a,b,c}$	-0.18^{a}	-0.06^{b}	-0.18^{c}

^{a,b,c,d,e,f} Means within a row with same superscript letters are statistically different ($\alpha = 0.05$, post-hoc Tukey HSD test).

Cluster 1, the largest segment or 33% of the sample, rated the perceived attributes of *training and assistance on how to produce* and *government subsidies or incentives* as the most important crop attributes (Table 5.5 and Figure 5.2). Therefore, this cluster was labelled the *program dependent cluster*. Members of this cluster also considered *high expected profit, good quality seeds,* and *cash opportunities* as important crop attributes.

Farmers in cluster 2, representing 29% of the sample, placed the attribute *high expected profit* as the most important crop attribute, followed by *stable and consistent price* and *stable and consistent yield* (Table 5.5 and Figure 5.2). Compared to the aggregate sample and other clusters, the attribute *high expected profit* had the highest mean BW score of any cluster. Therefore, this cluster was labelled the *profit maximiser cluster*. Crop attributes of least importance to this cluster were similar to the aggregate sample and the *program dependent cluster*.

Cluster 3, consisting of one fifth (20%) of the total sample, was labelled the *risk-averse cluster*. Members of this cluster perceived *stable and consistent price* and *stable* *and consistent yield* as the most important crop attributes, followed by *high expected profit, good quality seeds* and *training and assistance on how to produce* (Table 5.5 and Figure 5.2). Interestingly, members of this cluster rated the two attributes *cash opportunities* and *success of other farmers or neighbours* as the least important attributes.

Cluster 4, 18% of the sample, ranked *high expected profit* as the most important crop attribute (Table 5.5 and Figure 5.2).. However, relative to the aggregate sample and other clusters, this cluster was more concerned about *low initial investment or start-up costs* and *less labour*. This reflects concern regarding input use. Therefore, this cluster was labelled the *input minimiser cluster*. Interestingly, they were less concerned about *stable and consistent price* and *stable and consistent yield*, contrary to the *risk-averse cluster*.

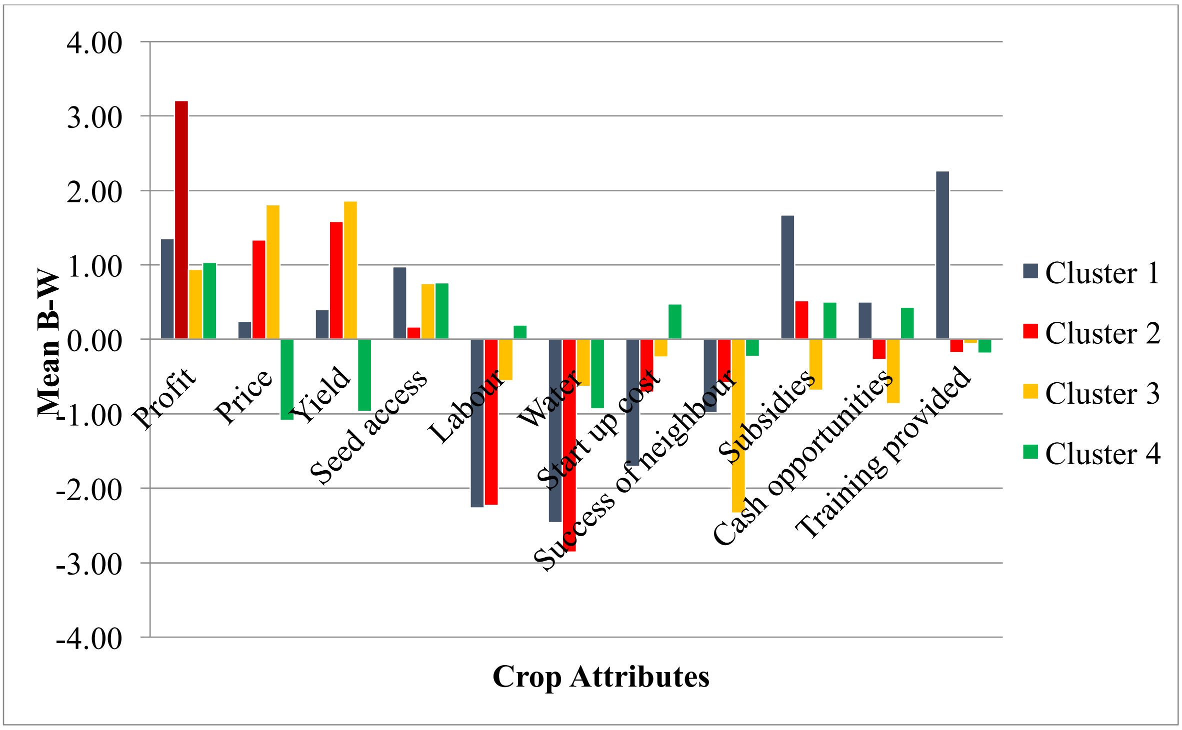


Figure 5.2. Summary of individual BW scores for each attribute (n = 960)

The analysis from LC clustering, as explained above, demonstrated significant differences in preferences for crop attributes across clusters. These results are similar to previous studies (Sahara, Umberger & Stringer 2013; Umberger et al. 2015; Wahida 2015) that found unique clusters of farmers with similar preferences for certain attributes. For example, Umberger et al. (2015) identified four unique clusters of Indonesian potato producers with different utilities for marketing channel attributes. In terms of heterogeneity in preferences for technology attributes, this finding was in line with Wahida (2015) who found three shallot producer segments in Indonesia with different preferences for crop and farming system attributes.

5.3.2.2 Characterising Four Farmer Clusters

The four unique clusters based on farmer preferences for crop attributes supported the existence of heterogeneity in the data and across farmers. Post-hoc Tukey's HSD t-tests were then used to test for significant differences in the four farmer clusters' characteristics with respect to household, farm and other socio-demographic dimensions. The results of the tests are provided in Table 5.6 and there were significant differences across clusters. These results are in line with recent studies (e.g. Sahara, Umberger & Stringer 2013; Umberger et al. 2015; Wahida 2015) reporting that farmer preference clusters had different household and socio-demographic characteristics. In this study, there were significant differences across the four clusters in terms of household, institutional and information factors, off-farm income and location dimensions. However, no significant differences were found with respect to farm characteristics, farm assets and on-farm income. The salient results are highlighted as follows.

Farmers in the *program dependent cluster*, placed a relatively high level of importance on the attribute related to whether subsidies or training are provided, and their spouses were more educated and had significantly more children living at home than other clusters (Table 5.6). Other main characteristics are that they have the highest proportion of members involved in producer organisations, such as a cooperatives or farmer groups (91%), and they were more likely to belong to a farmer field school (44% belonged) than other clusters. Thus considering their involvement in cooperatives or farmer groups perhaps offers opportunities for delivering government support and assistance programs such as training, subsidies and other technical assistance.

The key characteristics of the *profit maximiser cluster* are they have the highest dependence on agricultural activities and lowest share of horticultural income. Members of this cluster also have the highest share of rented land (15.4%) and irrigated land (58.2%) (Table 5.6).

The main characteristics of the *risk-averse cluster* are that they are the youngest farmers, who own more production and storage assets and have higher horticultural income. In addition, they have the highest proportion of members living in lowland areas (on average 157 m) and are located nearest to urban markets (on average 18.97 km) (Table 5.6).

In the small fourth cluster, the *input minimiser cluster*, the main characteristics are that this group is made up of the least educated and oldest farmers (Table 5.6). On average, they also have the highest share of off-farm income. Thus, this cluster appears less engaged with agricultural activities and could be identified as the ‘transition group’ to off-farm activities.

Table 5.6. Characteristics of LC clusters

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	
Name of Cluster	**Program Dependence**	**Profit Maximiser**	**Risk-Averse**	**Input Minimiser**	
Size of Cluster	33%	29%	20%	18%	
Variables	**Mean**	**Mean**	**Mean**	**Mean**	**F Value**
HH Characteristics					
Age HH (years)	50.80	52.90[a]	50.01[a,b]	53.31[b]	4.41***
Age spouse (years)	41.79	42.71	40.88	42.79	0.77
Education HH (years)	7.57[a]	7.28[b]	7.25[c]	6.36[a,b,c]	4.76***
Education spouse (years)	6.97[a]	6.41	6.71	6.05[a]	2.89**
Number of adult persons	2.99	2.90	2.88	3.07	1.40
Number of children	0.79[a]	0.61	0.76	0.57[a]	4.13***
Owns mobile phone (unit)	1.98	1.79	1.81	1.67	2.43*
Farm Characteristics and Farm Assets					
Farm size (ha)	0.75	0.76	0.75	0.80	0.22
% of rented land	13.30	15.22	14.13	11.02	0.72
% of irrigated land	55.63	58.15	55.02	55.78	0.25
Spouse managed at least one crop (1/0)	0.37	0.45	0.38	0.34	2.04
Engaged horticulture in 2007 (1/0)	0.42	0.43	0.35	0.36	1.90
Engaged horticulture in 2012 (1/0)	0.45	0.46	0.41	0.39	0.94
Transportation asset (million Rp)	7.70	7.34	9.09	10.81	1.26
Production asset (million Rp)	1.55	1.32	1.63	1.50	0.27
Storage asset (million Rp)	1.57	1.35	3.64	2.30	0.65
Institutional and Information Factors					
Received input credit (1/0)	0.13	0.10	0.10	0.09	0.64
Member of producer organizations (1/0)	0.91[a,b,c]	0.80[a]	0.78[b]	0.77[c]	7.87***
Received extension support (1/0)	0.20	0.21	0.15	0.15	1.29
FFS GAP/GHP (1/0)	0.11	0.06	0.11	0.09	2.00
FFS ICM (1/0)	0.44[a,b,c]	0.32[a]	0.31[b]	0.30[c]	4.74***
Income Activities and Location					
Net income (million Rp)	41.40	41.67	43.29	44.42	0.08
% of off-farm income	44.70	39.91	40.04	48.32	2.54*
% of horticultural income	12.05	-20.20	17.19	11.97	1.05
% of grain (rice, maize) income	47.79	96.27	75.39	64.28	1.00
Remittance income (million Rp)	0.80	0.83	1.00	3.67	1.97
Elevation (m)	215.26	186.96	157.71	223.52	2.11*
Distance to nearest urban market (km)	21.08	20.70	18.97	21.06	1.12

Notes: Based on ANOVA test: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. [a,b,c] Means within a row with same superscript letters are statistically different ($\alpha = 0.05$, post-hoc Tukey HSD test).

5.3.2.3 Adoption Behaviours of Four Farmer Clusters

As discussed above, the four farmer clusters have clear differences in preferences for crop attributes. This indicates their different conditions when considering the adoption of a new crop. This section highlights the actual adoption behaviour across four farmer clusters. The comparison of actual adoption behaviours across four clusters is presented in Table 5.7.

Results of the post-hoc Tukey HSD test show no statistically significant differences between the four clusters in relation to actual adoption behaviours (Table 5.7). Based on the binary adoption indicator, 13% of households in the *program dependent cluster* adopted at least one new horticultural crop from 2007 to 2012, followed by the *profit maximiser cluster* (11%), the *input minimiser cluster* (9%) and the *risk-averse cluster* (8%). Adoption rates of the *program dependent cluster* and the *profit maximiser cluster* were above the aggregate sample adoption rate (10.5%) as described in Section 4.3.3.1.

The average number of crops adopted by members in the *program dependent cluster* was the highest at close to 2 (Table 5.7). In terms of the timing of adoption, members of the *program dependent cluster* are more likely to be early adopters, while members of the *risk-averse cluster* are late adopters (laggards). On average, farmers in both of these clusters adopted at years 0.52 and 3.2, respectively.

Table 5.7. Adoption behaviour across the four clusters

	Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**	
Name of Cluster	**Program Dependence**	**Profit Maximiser**	**Risk-Averse**	**Input Minimiser**	
Size of Cluster	33%	29%	20%	18%	
Variables	**Mean**	**Mean**	**Mean**	**Mean**	**F Value**
New adopters (1/0)	0.13	0.11	0.08	0.09	0.99
Intensity of adoption (# of crops)	0.17	0.14	0.12	0.13	0.58
Timing of adoption (years)	0.52	0.41	0.35	0.32	1.14

5.4 Summary and Conclusions

An understanding of farmers' perceptions of agricultural technology attributes is important to address their needs when making adoption decisions. This chapter assessed the relative importance of 11 technology attributes important to Indonesian farmers when considering adopting a new crop. This chapter also examined whether farmers are heterogeneous in the relative importance to them of technology attributes, in this case crop attributes. This was conducted using a best-worst (BW) scaling task and latent class (LC) cluster analysis of individual best-worst scores. Clusters were characterised post-hoc using respondent characteristics, such as household, farm, socio-demographic and institutional factors and adoption behaviour.

The BW scaling method that allowed us to construct both aggregate and individual level rankings of farmer preferences for crop attributes. Not surprisingly, at the aggregate level, farmers exhibit strongest preferences for attributes related to *higher expected profit.* The attributes *stable and consistent yield* and *good quality seeds* are also considered as relatively important attributes to these Indonesian farmers. The crop attribute preferences include attributes related to *government subsidies or incentives to plant, training and assistance on how to produce,* and *low initial start-up cost.* These attributes address the different needs of farmers when making decisions to adopt a new crop.

LC cluster analysis was then conducted using the individual BW scores to explore farmer heterogeneity in preferences for crop attributes at the group (segment) level. Four distinct clusters of farmers were identified: *program dependent farmers* (33%), *profit maximisers* (29%), *risk-averse farmers* (20%) and *input minimisers* (18%). Each cluster has unique utilities for crop attributes and distinct socio-demographic characteristics. These characteristics were expected to provide insight on why a specific cluster of farmers perceive relatively higher or lower importance on certain crop attributes.

Results presented in this chapter suggest no significant differences existed in adoption behaviour across the four distinct preference clusters of farmers. However, these results are based only on comparisons of means across different clusters. In addition, these results do not necessarily reveal the net effects of preference clusters on adoption, because potentially confounding factors that drive adoption decisions have to be controlled for better measurement. Therefore, a rigorous econometric approach is required. The following Chapter presents an econometric analysis to estimate the effects of preference heterogeneity on three types of actual adoption behaviour. Results of LC clustering presented in this chapter are then incorporated into horticultural crop adoption models as explanatory variables. These findings are expected to provide better information for policy makers to encourage adoption of new technology amongst Indonesian farmers.

6 Chapter Six: Effect of Farmer Preferences for Crop Attributes on Horticultural Crop Adoption

6.1 Introduction

Chapter 5 examined heterogeneity in their preferences for crop attributes amongst Indonesian farmers on Java Island when they are considering adoption of a new crop. This study analysed distinct clusters of a sample of 960 Indonesian farmers regarding their preferences for crop attributes. An understanding of preferences for crop attributes is important to shed light on what is important to farmers when they are considering whether or not to adopt a new crop. An understanding of heterogeneity in farmer preferences for specific crop attributes supports a greater understanding among policy makers of decisions made by farmers at the group level. This could encourage greater adoption of high value horticultural crops.

As discussed in Chapter 2, a number of studies have addressed the role of preferences for specific technology attributes as factors influencing farmer adoption behaviour. However, heterogeneity in preferences for these technology attributes is rarely incorporated in technology adoption studies. To address this knowledge gap, this chapter integrates heterogeneity of preference clusters (groups) into adoption models to examine the effect of farmer preferences for specific crop attributes on their decision to adopt new horticultural crops.

This chapter addresses the third thesis objective, to examine determinant factors in horticultural crop adoption, particularly the effect of farmer preferences for specific crop attributes on horticultural crop adoption. In order to do that, this study integrated a unique best-worst (BW) scaling task to elicit farmer preferences for particular technology attributes and to better understand adoption behaviour. This study contributes to existing research by providing more comprehensive factors influencing agricultural technology adoption by integrating technology attributes with the other important factors such as farmer and household, farm and institutional characteristics as explained in Chapter 2.

In addition, this study contributes to existing research by addressing potential endogeneity of farmer preferences for technology attributes. While previous studies suggest the importance of technology attributes on technology adoption (e.g. Adesina & Zinnah 1993; Batz, Peters & Janssen 1999; Hintze, Renkow & Sain 2003; Lunduka, Fisher & Snapp 2012), this study is not aware of any study that addresses the potential endogeneity of farmer preferences for technology attributes. To deal with endogeneity, this study used a multinomial endogenous treatment (selection) model. This econometric analysis was used to estimate the effect of heterogeneity of preferences at the group (cluster) level, rather than the individual level, on adoption behaviour.

The study also contributes by utilising three distinct adoption indicators, recognising that the concept of adoption is complex and has many meanings. The first was a binary adoption indicator, which is most commonly used in the literature to explore drivers of adoption. The other two indicators were duration of adoption and intensity of adoption.

The remainder of this thesis chapter is structured as follows. Section 6.2 provides an overview of farm household survey data collected in Indonesia and methods include the conceptual framework, empirical specifications and variables used in the empirical model; this is followed by estimated results and discussion of results in Section 6.3. The summary and conclusion are presented in the final section.

6.2 Data and Methods

6.2.1 Data from the Indonesian Farmer Survey

As described in Chapter 3, this study used data from a 2013 survey of Indonesian farmers producing a variety of agricultural crops on Java Island, which has the largest production zone of horticultural crops in Indonesia. In the survey, farmers were asked about adoption decisions in the current cropping season, 2012/2013, and the adoption of new horticultural crops in the period from 2007 to 2012. This survey of 960 farmers included farmers that had adopted high value horticultural crops.

Data analysis generated a definition of adopter farmers based on respondent answers to a series of questions in the technology adoption section of the questionnaire (see Chapter 4). These questions covered whether the respondent had adopted new horticultural crops. If a respondent indicated 'yes' to the question, the respondent was classified as an adopter. From the answer to this question, this study identified 101 new horticultural crop adopter-farmers (10.5% of the sample).

6.2.2 Theoretical Models

To analyse adoption of new horticultural crops by Indonesian farmers, the study begins with a model of a farm household that maximises utility by choosing a production technology and a consumption bundle of goods while facing a number of market failures (Sadoulet & de Janvry 1995). This approach is appropriate as horticultural crop adoption represents a technology choice to be used in the farm household production system. The farm household maximises utility from consumption of goods (c) produced on-farm and purchased on the market. In addition, utility function is conditioned on a set of technology (crop) preference characteristics (α) to account for observable farm household level heterogeneity in the utility function. As explained in Chapter 2, farmer preferences for technology characteristics have become important for investigating farmer needs when making adoption decisions. However, no similar studies to date integrate these characteristics in adoption model. The objective of the farm household is to maximise this utility function by allocating factor inputs and a consumption bundle.

$$\max_{x,c} u(c, \alpha)$$

The farm household is constrained by a number of conditions, as follows:

(i) $\sum_{i \in T} p_i(x_i + E_i - c_i) + S \geq 0$, cash constraint for tradable goods

(ii) $\sum_{i \in TC} p_i(x_i + E_i - c_i) + R \geq 0$, credit constraint for tradable goods s.t. credit

(iii) $f(x, k) = 0$, a production technology

(iv) $p_i = \overline{p_i},\ i \in T$, an exogenous market price for tradable goods

(v) $c_i = x_i + E_i, i \in NT$, an equilibrium condition for non-tradables

where x>0 represents a good (horticultural crops) produced. E is the household initial endowment, which includes the endowment of labour. S is the net transfers received, such as remittance income. R is access to credit for goods that can be purchase on credit. $\overline{p_i}$ is the market price vector that the household faces at the time the household chooses vector x. K is the vector of fixed capital such as water pumps and farm land. H is the vector of household characteristics, for example household size and household education.

Thus, the farm household maximises utility subject to a number of constraints, such as cash, credit, and production technology. This study adapted the solution of the optimisation problem developed by Sadoulet and de Janvry (1995) suggesting that the adoption decision is modelled as a function of a set of variables measuring farm household incentives (p*) and farm household capacities (k). The optimal technology adoption model was determined as follows:

$$x^* = x(p^*, k)$$

where x^* is a variable indicating the adoption decision amongst farmers (e.g. adoption of high value crops), $p*$ is a vector of decision prices, and k is a vector of fixed farm household assets. Decision prices, $p*$, are a function of exogenous market prices ($\overline{p}$), capital endowment of the farm household (k), exogenous transfers (*S*), access to credit (*R*), farm household characteristics (H) and crop preference characteristics (α).

Hereafter, the study uses the term five broad categories of determinant factors frequently used in previous relevant adoption studies as explained earlier in Chapter 2: farmer household characteristics, farm characteristics, socioeconomic, institutional factors and information (Doss 2006; Feder, Just & Zilberman 1985; Knowler & Bradshaw 2007; Prokopy et al. 2008) to represent $\bar{p}$, k, S, R and H. Thus, the reduced form equation representing technology adoption is as follows, which the study specifies in the following estimable form:

$$X^* = X(\bar{p}, K, S, R, H, \alpha)$$

6.2.3 Empirical Models

As outlined in Chapter 2, there is a rich literature on technology adoption amongst smallholder farmers analysing why some farm households adopt new technologies while others do not (Doss 2006; Feder, Just & Zilberman 1985; Foster & Rosenzweig 2010; Knowler & Bradshaw 2007). However, preference heterogeneity for crop (technology) attributes (e.g. yield, government support), which affect how farm households adopt technology (Adesina & Zinnah 1993; Lunduka, Fisher & Snapp 2012), is seldom accounted for in cross-sectional models of technology adoption (Useche, Barham & Foltz 2009).

To account for unobserved heterogeneity in household preferences for crop attributes, this study utilised a latent class (LC) clustering method to examine variation across heterogeneous groups. Clustering analysis used individual scores for each BW scaling attribute, as explained in Chapter 5. These were then incorporated into the adoption decision model to explore the hypothesis that differences in farmer preferences for crop attributes affect adoption decisions of new horticultural crops. Integrating preference heterogeneity into models of new horticultural crop adoption enables more consistent estimation of parameters.

By including potential heterogeneity of preference parameters for crop attributes across farmers, the extended new horticultural crop adoption model was produced, as follows:

$$X_i^* = Z_i\beta + \alpha_j + \varepsilon_i$$

where i indices the farm households and j indexes the number of latent clusters; X_i is a vector representing adoption (i.e. binary adoption, intensity of adoption and duration of adoption); Z_i is a vector of farm household characteristics, farm characteristics, socioeconomic, institutional factors and information and α_j is a vector representing farmer preferences for crop attributes. This study uses the four unique clusters of farmers to account for farmer preferences for crop attributes as explained earlier in Chapter 5. With this specification, we are able to test the hypothesis that there are significant differences in farmer preferences for crop attributes at the group level that can affect adoption decisions. For example, the *risk-averse cluster*, which rated perceived attributes related to costs and risks as the most important attributes may be less likely to adopt new horticultural crops than other clusters.

6.2.4 Empirical Specification

This section addresses the empirical specification and discusses key variables used in the models. As described in Chapter 2, previous empirical studies used various methods to measure adoption behaviour, such as a binary decision (e.g. Hintze, Renkow & Sain 2003; Sahara et al. 2015), continuous process (e.g. Lambrecht et al. 2014) and intensity of adoption (e.g. Lunduka, Fisher & Snapp 2012; Vignola et al. 2010). In addition, a survey of literature since the mid-1980s on conservation agriculture adoption across the world by Knowler and Bradshaw (2007) showed that about one-half of those studies used a binary indicator of adoption. As discussed earlier, this study considered three different adoption indicators as a measure of adoption of a new horticultural crop. The main equation estimated is provided in equation (6.1).

$$Adoption_i = \beta Z_i + Cluster_j + \varepsilon_i \quad (6.1)$$

Table 6.1 shows descriptive statistics for dependent and independent variables included in the estimated regression models.

Table 6.1. Summary statistics for dependent and independent variables (n=960)

Variables	Mean	Std. Dev.
Adopters (dependent variable, 1 if adopted any new horticultural crops in 2007-2012, 0 otherwise)	0.11	0.31
Intensity of adoption (dependent variable, number of any new horticultural crops adopted in 2007-2012)	0.14	0.48
Timing of adoption (dependent variable, number of years from 1 to 6 if farmers started to adopt a new horticultural crop between 2007 to 2012 and 0 otherwise)	0.42	1.33
Age HH (years)	51.69	11.22
Education HH (years)	7.21	3.41
Number of adult persons living in the household	2.95	1.03
Agriculture assets		
Transportation assets, e.g. motorcycle, truck, cart (million Rp)	8.42	20.16
Production assets, e.g. water pump, sprayer, tractor (million Rp)	1.49	3.94
Storage assets, e.g. storage house (million Rp)	2.05	18.99
Farm size (ha)	0.76	0.77
% of land that is rented	13.63	29.88
% of land that is irrigated	56.27	43.79
Remittance income (million Rp)	1.35	13.69
Distance to nearest urban market (km)	20.54	13.59
Elevation (m)	196.82	295.49
Access to extension (1 if received information about horticultural production from extension officers, 0 otherwise)	0.19	0.39
FFS GAP/GHP (1 if participated in Farmer Field School-Good Agricultural Practices/Good Handling Practices for horticultural crops, 0 otherwise)	0.09	0.29
FFS ICM (1 if participated in Farmer Field School-Integrated Crop Management for staple food crops, 0 otherwise)	0.36	0.48
Membership in producer organisations (1 if members of cooperative or farmer group, 0 otherwise)	0.83	0.38
Role of spouse (1 if spouse managed at least one crop, 0 otherwise)	0.39	0.49
Experienced adopters (1 if produced any horticultural crops in 2007, 0 otherwise)	0.40	0.49
Crop Preference-Cluster	**Freq.**	**%**
Program dependent cluster	318	33
Profit maximiser cluster	280	29
Risk-averse cluster	194	20
Input minimiser cluster	168	18

In equation (6.1), the vector, $Adoption_i$ represents the adoption decision of the respondent, farmer *i*. Three different specifications of $Adoption_i$ are used. First, the variable takes on the value of one if the farmer household adopted a new horticultural crop in the period from 2007 to 2012, and 0 otherwise. Thus, farmers who adopted any new horticultural crops in that period were identified as 'adopters[23]', while farmers who had never adopted those crops from 2007 to 2012 were coded as 'non-adopters'. Based on that classification, 10.5% of farm households adopted at least one new horticultural crop from 2007 to 2012. Second, this study generated a continuous variable to represent intensity of adoption. This dependent variable represents the number of new horticultural crops adopted by farmers in the period from 2007 to 2012. The average number of crops adopted by 960 sample farmers was 0.14 and for 101 adopters was 1.36. Third, this study used the timing of adoption variable, which indicated when farmers adopted a new horticultural crop. In enumerating the years of adoption by farmers, this study used the value of 1 to 6 if the farm household adopted a new horticultural crop from 2007 to 2012, consecutively, and 0 otherwise. This variable was used to identify early adopter farmers and adoption laggards. The average years of adoption by the sample of 960 farmers was 0.41 and it was 3.95 for the sample of the 101 adopters.

The explanatory variable of interest, $Cluster_j$, is a set of dummy variables representing preference-clusters. As discussed earlier in Chapters 2 and 5, one of the major reasons that this study is interested to examine preference-clusters is as shown by recent studies on farmer preferences for certain attributes confirm that heterogeneities exist amongst farmers (e.g. Umberger et al. 2015; Wahida 2015). The study hypothesis was that adoption behaviour differs across preference-clusters. For example, cluster of risk-averse farmers may have lower propensities to adopt new horticultural crops than other clusters because these crops are riskier. On one hand, cluster of program dependant farmers tend to

[23] Note that adopters of new horticultural crops are not farmers who had never cultivated horticultural crops previously. There were 62 of 101 adopters who had cultivated different horticultural crops in previous seasons or years.

have more likely to adopt new horticultural crops than other clusters. A detailed explanation of how this variable was generated is presented earlier in Section 5.2.3.

However, it is important to note that the main methodological issue related to the model estimated using equation (6.1) is endogeneity of α_j, the farmer crop preference cluster. This explanatory or treatment variable (α_j) is endogenous when it is significantly correlated with the error term (residuals) of the estimated regression model for horticultural crop adoption (the dependent or outcome variable). It is commonly known as endogenous treatment effects and selection bias (Peel 2014). This endogeneity also arises where there is simultaneous causality bias. This occurs when farmer adoption behaviour (the outcome variable) determines preferences (the treatment variable) and vice versa. In this case, ordinary least squares (OLS) estimation is biased. Where the dependent or outcome variable is continuous or binary and the explanatory variable is a multinomial selection variable, the multinomial endogenous treatment model is used in this study to control for endogeneity between adoption behaviour and crop preference cluster (Peel, 2014). The multinomial endogenous selection model is explained in Section 6.2.5.

The vector Z_i represents control variables, covering farmer household characteristics, farm characteristics, socioeconomic, institutional factors and information. A detailed explanation for each category is provided below.

Farm household characteristics include age of household head, years of education completed by household head, and number of people in the household over 15 years of age as proxy for household labour endowment. Farm characteristics include farm size, land tenure, and share of irrigated land. Within these characteristics, this study included productive capital endowment calculated as the sum of values of three agricultural assets, namely transportation, production and storage assets. Socioeconomic factors include elevation and distance to markets, reflecting location and accessibility of markets. Within these characteristics, this study included a variable to account for total remittance income a household receives to control for exogenous shocks to farm household income. This income source may help farm households make initial investments necessary when adopting a new horticultural crop.

Another control variable, institutional factors, includes farm household participation in Farmer Field School-Global Agriculture Practices/Good Handling Practices (FFS-GAP/GHP) for horticultural crops and FFS-Integrated Crop Management (FFS-ICM) for staple food crops. Within these categories, this study also included membership of a producer organisation, such as farmer groups, cooperatives, water use associations and female farmer groups. This membership variable is both a proxy for collective action and an indicator of accessibility of government programs and information related to production methods, markets and new technologies. For information factors, this study included a dummy variable indicating whether the farm household received information about horticultural crop production from extension officers.

To control for experience and knowledge of the farm household to grow a horticultural crop, this study generated a dummy variable called 'experienced adopters' which took a value of one if the farm household was engaged in horticultural crop production in 2007 and 0 otherwise. In the sample used for this study, 62 of 101 adopters were also previous adopters. This means that 62 adopters already produced a horticultural crop in 2007 and in the meantime they also adopted a different new horticultural crop.

6.2.5 Multinomial Endogenous Treatment Model

In this study, the horticultural crop adoption model was estimated including all control variables explained above and crop preference cluster variables. The estimation model was presented in equation (6.1) above. The main methodological issues related to this estimation model lie in the endogeneity of α_j, farmer crop preference cluster. It seems to be a reverse causality between farmer preferences and adoption. Farmer preferences affect adoption behaviour, but farmer adoption behaviour may also influence changing preferences.

As explained above, to address this endogeneity issue and given the multinomial selection variables, this study used a multinomial endogenous treatment effect model developed by Deb and Trivedi (2006a) to estimate model parameters. This model, an extended model of the Heckman treatment effect method (Peel 2014), is the most suitable method this study is aware of that is also relevant for our case. According to Deb and Trivedi (2006a), this multinomial endogenous treatment model accommodates correlated endogenous sorting into different treatments. In this study, farmer preference-clusters classified by similar farmer preferences using LC cluster analysis (see Chapter 5) were considered treatments (selection variables) in the model.

In the estimation, this model consisted of a two-step regression model, which included selection and outcome equations that were estimated simultaneously. The first-step regression model where farmer preference-clusters are specified as the dependent variable is employed and the specification accounts for endogeneity and unobserved bias. The errors (unexplained variation in farmer preference-clusters) from this model are then used as a surrogate for omitted variables in the second-step outcome regression model for adoption behaviour. Furthermore, this estimation was used to analyse effects of an endogenous multinomial treatment (selection) on binary and continuous outcome variables.

As explained previously, outcome variables in this study include a binary variable (adoption decision, 1/0) and two continuous variables (years of adoption and number of crops adopted). The selection variables, in multinomial form, are represented by number of preference cluster variables specified as N-1 (the base case) binary variables. More precisely, the outcome equation, an adoption equation, is written as equation (6.1) above and the selection equation, a multinomial logit, is provided in equation (6.2), as follows:

$$Cluster_i = \gamma Z_i + v_i \qquad (6.2)$$

This method controls for selection bias by allowing the error term in the selection equation (multinomial logit) to be correlated with the error term in the adoption equation. This model is estimated by using maximum simulated likelihood that uses Halton draws to ensure convergence (Greene 2003). The method is implemented with the Stata mtreatreg command.

To test the effect of preference clusters on adoption behaviour, this study used one cluster as the base cluster to test whether parameters were different across clusters [H_0: $\alpha_j = 0$]. This allowed the effect of crop preference-clusters on adoption behaviour to vary across adoption models. Significant preference-clusters ($\alpha_j \neq 0$) indicated that crop attribute preferences were a significant source of unobserved heterogeneity in cross-sectional horticultural crop adoption models.

6.3 Results and Discussion

This section presents regression results of the effect of crop attribute preferences on horticultural crop adoption. This section also discusses differences across four unique clusters in the adoption of new horticultural crops. In addition, this section discusses the effect of other control variables on adoption behaviour.

6.3.1 The Effect of Preference Cluster on Adoption

Multinomial endogenous treatment estimations were applied to test whether horticultural crop adoption behaviour was uniform across preference clusters, or whether adoption behaviour varies across clusters. In these estimations, the study set the *profit maximiser* cluster as the reference group and interpreted other clusters, namely *program* *dependent, risk-averse* and *input minimiser* clusters, as three different groups with differential effects on adoption behaviour. Table 6.2 shows complete results of maximum simulated likelihood estimates from multinomial endogenous treatment estimations.

Overall, results show that the preference-cluster effect varied across three different adoption models. First, an insignificant preference-cluster effect was found for the binary model (Table 6.2). To validate further, the study conducted a post-estimation test parameter with the null hypothesis that preference-cluster coefficients are jointly equal to zero. In other words, this test was conducted to identify whether the effects of farmer crop preference clusters were different in the binary model. However, results also showed no difference in preference-cluster effect. This means that, compared to the base cluster (*profit maximiser cluster*), there is no evidence that farmers in other clusters, namely *risk-averse, program dependent cluster* and *input minimiser* clusters differ in their adoption behaviour.

Second, a significant preference-cluster effect was identified in the intensity and timing adoption models (Table 6.2). However, the effects of farmer crop preference clusters were different across those models. Compared to the base cluster (*profit maximiser cluster*), farmers in the *risk-averse cluster* were more likely to adopt at a later time. This may be due to the high risk of shifting to a new horticultural crop. This result is consistent with findings of previous studies that suggest risk and uncertainty have important roles in agricultural technology adoption, including timing of adoption (Marra, Pannell & Ghadim 2003). Moreover, farmers in the *risk-averse cluster* were less likely to adopt new technologies that increase yield variance, especially in the early adoption process (Jack 2011). However, at the same time, farmers in this cluster were more likely to adopt multiple new crops than other clusters. This is an interesting result, supporting the literature on adoption that suggests farmers need to take up risk coping strategies to overcome adoption constraints imposed by risk (Jack 2011). For farmers in this cluster, adopting multiple horticultural crops may reduce risk through diversification, as where one new crop fails, perhaps others will not.

Farmers in the *program dependent cluster* were more likely to be early adopters (Table 6.2). Their likelihood to be early adopters may be as they are more willing to seek out government and non-government programs. This means that access to training programs and subsidies may influence uptake of new horticultural crops giving this group more confidence to be early adopters. In other words, the crops supported by government and non-government assistance are preferred by farmers in this cluster. However, in Indonesia only certain horticultural crops, known as *komoditas hortikultura unggulan* – competitive horticultural crops, are commonly supported by programs. Examples of Indonesia's competitive horticultural crops enacted by the GoI are chillies, shallots, potatoes, mangoes and mangosteens. In addition, developments of *komoditas hortikultura unggulan* are regional or local-specific, known as *kawasan hortikultura* – horticultural regions. Therefore, region-based programs may explain why farmers in this cluster are less likely to adopt a number of new horticultural crops.

Interestingly, this study found that farmers in the *input minimiser cluster* were more likely to adopt at an earlier time, but less likely to adopt multiple new horticultural crops (Table 6.2). A potential explanation for this finding may be that this group was more concerned with the attributes related to production constraints or costs (*seed access, low-investment technologies* and *labour saving)* as the most important crop attributes when adopting a new crop. These farmers may consider not adopting multiple new horticultural crops as the production cost of horticultural crops is relatively higher than for staple food crops (Birthal et al. 2013; Joshi, Joshi & Birthal 2006). According to Minot and Roy (2007) and Joshi, Joshi and Birthal (2006), relative to rice and other staple food crops, horticultural crops such as vegetables are more labour intensive in activities such as planting, harvesting and post-harvest handling. Thus, crop-wise labour use plays an important role in deciding the production-portfolio for the *input minimiser cluster*. In addition, Joshi, Joshi and Birthal (2006) suggest that availability of good quality seeds could be crucial constraints faced by smallholders in horticultural adoption.

Table 6.2. Multinomial endogenous treatment results

Dependent Variable	New adopters (1/0)		Intensity of Adoption		Timing of Adoption (years)	
	(1)		(2)		(3)	
Age HH (years)	-0.032**	(0.015)	-0.003**	(0.001)	-0.004	(0.004)
Education HH (years)	0.067	(0.042)	0.008	(0.006)	0.021	(0.015)
Number of adult persons	0.184	(0.120)	0.002	(0.013)	0.054	(0.040)
Transportation asset (million Rp)	-0.032*	(0.019)	-0.001	(0.001)	-0.002	(0.002)
Production asset (million Rp)	0.055*	(0.029)	0.004	(0.003)	0.010	(0.012)
Storage asset (million Rp)	0.009**	(0.004)	0.002***	(0.001)	0.002*	(0.001)
Farm size (ha)	0.014	(0.144)	-0.010	(0.019)	0.001	(0.049)
% of rented land	0.011**	(0.005)	0.002**	(0.001)	0.006***	(0.002)
% of irrigated land	-0.002	(0.003)	0.000	(0.000)	-0.002	(0.001)
Remittance income (million Rp)	-0.024	(0.054)	0.000	(0.001)	0.001	(0.002)
Distance to nearest urban market (km)	0.012	(0.009)	0.002	(0.002)	0.009*	(0.005)
Elevation (m)	0.001***	(0.000)	0.000**	(0.000)	0.001**	(0.000)
Received to extension support (1/0)	1.249***	(0.424)	0.162***	(0.062)	0.492***	(0.191)
FFS GAP/GHP (1/0)	0.772*	(0.401)	0.081	(0.063)	0.114	(0.201)
FFS ICM (1/0)	-0.547*	(0.327)	-0.059	(0.036)	-0.049	(0.121)
Member of producer organisation (1/0)	1.090**	(0.485)	0.090**	(0.040)	0.342***	(0.103)
Role of spouse (1/10)	0.123	(0.250)	0.039	(0.034)	-0.042	(0.093)
Experienced adopters (1/0)	0.514	(0.334)	0.019	(0.044)	0.059	(0.125)
Constant	-3.933**	(1.197)	0.034	(0.133)	-0.320	(0.382)
Treatment Effect						
Profit maximiser cluster (base category)						
Program dependent cluster	0.046	(0.417)	-0.074	(0.054)	-0.249*	(0.136)
Risk-averse cluster	0.391	(1.117)	0.195***	(0.045)	0.815***	(0.126)
Input minimiser cluster	-0.283	(0.653)	-0.092*	(0.048)	-0.386**	(0.154)
ln sigma			-1.039***	(0.088)	-0.570***	(0.102)
λ Program dependent cluster	0.100	(0.355)	0.116***	(0.035)	0.448***	(0.135)
λ Risk-averse cluster	-0.839	(1.209)	-0.262***	(0.035)	-1.001***	(0.079)
λ Input minimiser cluster	0.316	(0.580)	0.119***	(0.026)	0.476***	(0.129)
Sigma			0.354	(0.031)	0.565	(0.058)
Number of obs	960		960		960	
Wald chi2(75)	160.64***		257.9***		259.13***	
Log pseudolikelihood	-1521.87		-1844.87		-2816.80	

Notes: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors presented in parentheses. In this estimation, the study used 10000 Halton sequence-based quasi random draws per observation. This study used logit outcome density for model 1 and normal for others. Standard deviation of factor density is 1.

6.3.2 Effect of Other Characteristics on Adoption

Regression analysis results show that government extension services had a significant positive effect on horticultural adoption across all models (Table 6.2). In addition, farm households with younger heads of household were significantly more likely to adopt multiple new horticultural crops. These findings indicate that technical programming is effective in promoting the adoption of new horticultural crops and younger farmers are the most suitable targets for promotion of new horticultural crops.

Other results show that membership in producer organisations had a significantly positive effect on horticultural crop adoption for all models (Table 6.2). This suggests that producer organisations make an effective contribution to new horticultural crop adoption. For the effects of farmer field school on horticultural crops (FFS GAP/GHP), this study found a positive response in all adoption models. This farmer field school provides knowledge to farmers regarding horticultural production possibilities (available technologies), which makes it easier for farmers to shift to desired horticultural crops. Conversely, the effects of farmer field school on staple food crops (FFS ICM) has a negative influence on new horticultural crop adoption. This is not surprising because FFS ICM is aimed at farmers of staple food crops, such as rice, maize and soybean.

Another result showed that farm size had no significant effect on the three adoption models (Table 6.2). This means that smallholder farmers are not excluded from participation in new horticultural crop adoption.

6.3.3 Identifying Conditions

Results also show that the endogeneity test of preference cluster parameters varied across models (Table 6.2). For the binary model, the null hypothesis that the preference-cluster lambdas (λ) are simultaneously equal to zero was accepted. This means that there was no evidence of endogeneity (Deb & Trivedi 2006a, 2006b) in the binary adoption model. Conversely, this study found strong evidence of endogeneity of the preference-cluster for the duration and intensity of adoption models. The null hypothesis that the preference-cluster lambdas (λ) are simultaneously equal to zero was rejected in those models at one per cent level of significance. These results indicate that the traditional adoption model, ignoring potential endogeneity of the preference-cluster, may be appropriate for the binary decision model. On the other hand, accounting for the endogeneity of the preference-cluster could be considered when estimating the intensity and timing of adoption models.

6.4 Summary and Conclusions

This chapter adds to previous adoption studies by examining adoption behaviour as a function of preferences for technology attributes, as well as farmer and farm characteristics. This study tested the effect of farmer preference heterogeneity at the cluster (segment) level rather than at the individual level. Potential endogeneity of farmer preferences for technology attributes was addressed using a multinomial endogenous treatment model. The multinomial endogenous treatment regressions showed that preference cluster effects varied across models. Product-preference cluster had no significant effect on adoption measured as a binary variable, that is adopt or not adopt. The product-preference cluster did have a significant effect on intensity of adoption and timing of adoption. These results indicate that how farmer preferences for crop attributes affect their actual behaviour. For example, compared to the base cluster (*the profit maximizer cluster*), while farmers in *the risk-averse cluster* are more likely to adopt at a later time, farmers in *the program dependent cluster* are more likely to adopt at a shorter time. These findings inform the policy makers to encourage greater adoption of horticultural crops by a greater understanding among them of decisions made by farmers at the group level.

Therefore, the findings allow more targeted programming to encourage farmers to adopt horticultural crops that have a high probability of offering benefits.

Examining the effect of farmer preferences for crop attributes is important in understanding the adoption process. Targeting farmers in the *risk-averse cluster* may be a better strategy to promote sustainable horticultural development in Indonesia. These are farmer households that are highly concerned with *stable and consistent price* and *stable and consistent yield*, followed by *high expected profit, good quality seeds* and *training and assistance on how to produce*. These households tend to be younger and have more agricultural assets. In addition, they tend to adopt multiple horticultural crops, but are also relatively slow to adopt new horticultural crops. Thus, for horticultural development programming to be more effective depends on strategies to help this group of farmers adopt earlier. Targeting this cluster to diversify towards horticulture is also consistent with recommendations of a report by (IFPRI 2015) suggesting that public policy makers should support farmers in *moving up* to more profitable farming activities.

While some farmers may have the potential to successfully diversify into horticulture, others may not. That is, not all programming and policy works similarly for all farm households. Thus, targeting farmers in other clusters may not be the best strategy to promote sustainable horticultural development in Indonesia. For example, farm households in the *program dependent cluster* represented the largest proportion of farmers to consider to growing a new horticultural crop if subsidies or training are provided, suggesting that they are unstable adopters. Another cluster, the *input minimiser cluster*, was less engaged with agriculture activities. In other words, they could be identified as the 'transition group' to off-farm activities. Thus, instead of encouraging them to engage in on-farm activities, it may be better targeting the *input minimiser cluster* to seek off-farm employment opportunities. This recommendation is consistent with another recommendation of a report by IFPRI (2015) suggests that public policy makers should support farmers in *moving out* of agriculture.

Overall, study findings suggest that knowledge about important crop attributes and heterogeneity amongst farmers would help policymakers, extension and agricultural development specialists to encourage smallholder farmers to adopt horticultural crops. These findings also allow more targeted policy and development programs, by designing incentives and information on specific cropping attributes that are most likely to encourage farmers to adopt crops that have a high probability of offering benefits, resulting in improved livelihoods for smallholders.

7 Chapter Seven: Impact of Horticultural Crop Diversification on Farm Household Food Supply and Income[24]

7.1 Introduction

As described in Chapter 1, the agricultural food transformation in Indonesia towards high value agricultural products, such as fruits and vegetables, offers potential for diverse food supply and economic benefits to smallholder farmers. Chapters 4, 5 and 6 dealt specifically with Indonesian farmer adoption decisions responding to growing demand for high value horticultural crops. This chapter 7 focuses on how and in what ways small farm household diversification into horticultural production significantly affects farm household food supply and income.

When examining potential food supply and financial benefits derived from horticultural crop diversification, it is essential to recognise that the Government of Indonesia (GoI) prioritises staple food crop production by supporting farmers to achieve national self-sufficiency in vital staple food crops such as rice, maize and soybeans, as reflected in current national policy. This policy provides farmers with a wide range of extension programs, subsidies, and products designed to offer assistance in staple food production. While self-sufficiency in staple foods is secure, the policy may have negative consequences for farmers seeking to respond to growing demand for horticultural crops.

The impact of strong government support for staple food crop production on small farm households' value of production and income is largely unknown. At the same time, the impacts of horticultural diversification on the value of small farm production and household income are also unknown. This chapter addresses the question in the fourth objective of this study by specifically analysing the impact of horticultural crop

[24] An earlier version of this chapter was presented at two international conferences: (1) the 2nd International Conference on Global Food Security, 11-14 October 2015 at Cornell University, Ithaca, New York, USA; (2) the 60th Annual Conference of the Australian Agricultural and Resource Economics Society (AARES), 2-5 February 2016 in Canberra; (3) the joint collaboration of 26th Annual IFAMA World Conference & 12th Wageningen International Conference on Chain and Network Management (WICANEM), 19-23 June 2016 in Aarhus, Denmark.

diversification on small farm household food production and income. In doing so, this thesis chapter addresses three specific research questions not sufficiently explored in previous literature, as follows:

Research question 1: How does diversifying into horticultural crops affect farm household food supply of (a) horticultural crops such as fruits and vegetables; (b) staple food crops such as rice and maize, and; (c) estate crops such as sugarcane?

When a small farmer incorporates one (or more) horticultural crop(s) into their farming system, resources allocated to produce non-horticultural crops may be reduced. Thus, there is a trade-off when a farm household expands horticultural production. Horticultural diversification may associate negatively with supply of staple food crops, such as rice, and estate crops, such as sugarcane. However, there is no known research that sheds light on the trade-offs between horticultural crop diversification versus staple food crops and estate crops.

Research question 2: How is farm household wage income affected by diversifying into horticultural crop production?

The impact of horticultural crop diversification on wage income has not been assessed and it is unknown whether diversification toward high value horticultural crops impacts rural labour supply. Horticultural crop diversification may affect distribution of labour within the farm household. As explained in Chapter 1, the potential benefits of higher value horticultural crops may attract small farmer household members to engage in horticultural production as rural labour instead of participating in off-farm activities, such as non-agricultural wage-employment or self-employment in commerce (Jarvis & Vera-Toscano 2004; Joshi, Joshi & Birthal 2006).

Research question 3: What are the net impacts of horticultural crop diversification on farm household (a) food supply, and; (b) income?

The impact of horticultural crop diversification can be analysed for farm household food supply and income. Whether there is a net positive impact from diversifying production to include horticultural crops, such as fruits and vegetables, is under-researched in Indonesia. Whether shifting to horticultural crops can raise small farm household income is debatable, especially when considering constraints, such as lack of access to production inputs and markets. As described in Chapter 2, participation in higher value horticultural chains is not always associated with higher economic benefits to smallholder farmers (Narayanan 2014).

To address the chapter objective, a unique primary dataset from a survey of farmers on Java Island, Indonesia was analysed. Java is an appropriate setting as this area is a major production zone in Indonesia, for both staple food crops and horticultural crops. Indeed, this area is one of the targeted regions for the '*Upsus Pajale*' program. The remainder of this chapter is structured as follows: Section 7.2 provides an overview of data used in analysis, theoretical models and estimation methods, followed by estimated results and discussion in Section 7.3. The summary and conclusion are presented in Section 7.4.

7.2 Data and Methods

7.2.1 Farm Household Survey

This chapter presents analysis of primary data obtained from the authors' survey of Indonesian household farmers conducted in 2013 on Java Island, Indonesia, as described in Chapter 3. The research area covers six districts, which include some of Indonesia's major rice bowl areas, such as Demak and Subang. The sample includes 960 smallholder farmers selected from highland and lowland regions, drawn from a systematic random sampling procedure. The sample of farm households accounts for a significant variety of crops and cropping patterns.

The survey questionnaire captured data on household demographics, assets, agricultural land, various farm and off-farm income sources, and detail on access to government programs. The questionnaire also included an agriculture production module, which provided information used to calculate farm household food supply for both horticultural and staple food crops. In the context of this study, fruits and vegetables were classified as horticulture and tubers, such as potato, were considered vegetables rather than staple foods.

7.2.2 Theoretical Models

In order to test the relationship between horticultural crop diversification and measures of livelihoods, the study adapted the agricultural household model framework of Sadoulet and de Janvry (1995) as in Chapter 6. The farm household chooses a production technology and a consumption bundle of goods while facing a number of market failures. Hence, this approach is appropriate as horticultural crop diversification (adoption) represents a technology choice to be used in the farm household production system. The farm household allocates farm land and organises family and hired labour to maximise utility from consumption of goods (c) produced on-farm and purchased on the market. In addition, utility function is conditioned on a set of farm household characteristics (H) to account for observable farm household level heterogeneity in the utility function. The objective of the farm household is to maximise this utility function by allocating factor inputs and a consumption bundle. The equation below was used to determine utility function for farm households.

$$\max_{x,c} u(c, H)$$

The farm household is constrained by a number of conditions, such as full-income budget constraints including cash and credit constraints and production technologies. Therefore, the farm household maximises utility subject to these constraints. This study adapted solution of the optimisation problem developed by Sadoulet and de Janvry (1995) suggesting that farm household food production (X) is modelled as a function of a set of vectors of agricultural technologies used in production of good (Z) representing exogenous market prices ($\bar{p}$), capital endowment of the farm household (k), exogenous transfers such as remittances (S), access to credit (R) and farm household characteristics (H); and fixed amount of inputs or assets ($\bar{h}$) including public factors (e.g. infrastructure, extension services) and exogenous features (e.g. elevation and distance to markets). In this study, agricultural technology use includes horticultural crop diversification (adoption) (D).

Following a similar procedure as explained in Section 6.2.2., thus, the reduced form equation representing farm household production is as follows:

$$X^* = X(\bar{p}, K, S, R, H, D)$$

7.2.3 Empirical Models

The empirical equations representing farm household production (output supply) is expressed as:

$$X_i = Z_i\beta + D_i\gamma + \varepsilon$$

where i indices the farm households; X_i is a vector indicating farm household food production (output supply); Z_i is a vector of farm household characteristics, farm characteristics, socioeconomic, institutional factors and information; and D_i is a variable indicating the horticultural diversification (adoption) decision amongst farmers. In this study, horticultural crop diversification (D_i) is defined as type of agricultural technology adoption which is new farming system technologies. The farm household decision to diversify into horticultural crops will affect the input factor allocation for production of staple food crops. This means that the allocation of an input factor to produce horticultural crops will influence another input factor to produce non-horticultural crops.

7.2.4 Estimation Strategy

This section addresses the empirical specification and discusses key variables used in the models. The study estimates a linear specification of the equation given below:

$$X_i = Z_i\beta + Diversification_i\gamma + \varepsilon_i \qquad (7.1)$$

The dependent variable, X_i, is a measure of food production, where i indices farm households. In this study, the farm household food production is measured in one value, which is in Indonesian rupiah, as there are different kinds of agricultural crops produced by farm households. As explained above, this study examines the impact of horticultural crop diversification on different groups of food supply and food income such as staple food crops (e.g. rice and maize), horticultural crops (e.g. vegetables and fruits) and estate crops (e.g. sugarcane and tobacco). Therefore, X_i consists of (1) value of horticultural supply, (2) value of staple food supply, (3) value of estate crop supply, (4) on-farm income from horticultural crops, (5) on-farm income from staple food crops, (6) on-farm income from estate crops, and (7) wage income. This study used value of production and net income per hectare, which are calculated by dividing the value of production (and net agricultural income) by farm size.

The explanatory variable of interest, $Diversification_i$, is the share of total farm household farmed land allocated to horticultural crop production. To determine horticultural producers, the study enumerated each household that reported producing a type of horticultural crop on their farm over the 2011-2012 rainy season and 2012 dry season. In our data set, 382 of 960 sample farmers (39.8%) allocated land to horticultural crop production, hereafter, classified as horticultural farmers[25].

The vector Z_i represents control variables, which represent the five broad categories of determinant factors frequently used in previous relevant food production, income and

[25] The study dropped one farmer who had a big negative horticultural income from the sample (outlier). Thus, the total sample of horticultural farmer is 381 farmers.

crop diversification studies: (1) farmer (household) characteristics, (2) farm characteristics, (3) socioeconomic factors, (4) institutional factors and, (5) information (e.g. Birthal et al. 2013; Pellegrini & Tasciotti 2014; Rao & Qaim 2011; Sichoongwe et al. 2014) as explained in Chapter 6.

This study estimates the model using simultaneous equations regressions, a three-stage least square (3SLS) estimation, using a separate system for each measure of livelihoods, food supply and income. The main reason of using 3SLS estimation is because it produces better standard errors than other estimations such as 2SLS estimation (see Wooldridge 2010). In addition, 3SLS generates consistent estimates of the parameters that are more efficient than those generated by 2SLS. The study also separately estimates those two systems, food supply and income models, for different agro-ecological zones (AEZs), lowland and non-lowland areas. This parallel to the sampling selection in this study that used elevation for stratification as explained in Chapter 3. The non-lowland areas included medium and highland areas, as described in Chapter 3, hereafter labelled highland areas. The main reason of this disaggregation is that elevation can play an important role influencing cropping systems. In addition, lowland areas in Indonesia are the key areas for producing staple food crops and are designed to support by the national program called '*Upsus Pajale*'. Hence, it is of interest to know more about different effects of horticultural crop diversification by elevation.

The coefficients on $Diversification_i$ (γ) are the parameters tested in the rest of this chapter, hereafter, referred to as test of food supply and income effects. First, the study tests the magnitude of each γ (H_0: $\gamma = 0$) in all equations. For horticultural supply and income, it is expected that the coefficients on $Diversification_i$ (γ_H) will be significant and positive. The positive coefficients indicate that higher diversification into horticultural crops is associated with higher horticultural supply and income. On the other hand, when examining staple food and estate crop supply and income, it is expected that the coefficients on *Diversification$_i$* (γ_S) and (γ_E) will be significant and negative. Negative coefficients indicate a trade-off between staple food supply and estate crops versus horticulture crop diversification. For wage income estimation, the study expects that the coefficient on *Diversification$_i$* (γ_W) will be positively or negatively significant.

Second, the study also compares relative magnitudes of diversification coefficients to identify overall loss or gain in value for the average farm household. For food supply effects, the study tests the net effects using the sum of γ which are net effects on farm supply ($H_0: \gamma_H + \gamma_S + \gamma_E = 0$) and total net effect ($H_0: \gamma_H + \gamma_S + \gamma_E + \gamma_W = 0$). Similarly, those net effects on income equations are tested.

The estimations used in this study are likely to be biased and inconsistent due to the *Diversification$_i$* measure, which is likely to be endogenous. This correlation may be a result of reverse causation, in which farm household food supply and farm household income may influence diversification decisions. Farm households most productive in food supply may diversify production systems towards horticultural crops. Similarly, farm households who earn high income may also diversify towards horticulture. Where the dependent variables (farm household food supply and farm household income) and the explanatory variable (horticultural crop diversification) are both continuous, three-stage least squares (3SLS) simultaneous equation models were used in order to control for the endogeneity (as explained above). Furthermore, to address issues resulting from reverse causality, this study uses instruments strongly correlated with the endogenous variable, *Diversification$_i$*, but uncorrelated with the error term in the food supply and income equations. Specifically, as discussed below, the instruments must be independent from the farm household food supply and farm household income variables other than via its correlation with the horticultural crop diversification variable.

There are three different groups of food supply and food income such as staple food crops (e.g. rice and maize), horticultural crops (e.g. vegetables and fruits) and estate crops (e.g. sugarcane and tobacco). Therefore, three sets of instruments were used in the 3SLS simultaneous equation models. The first group of instruments correlating to horticultural crop diversification, but not related to staple food production and/or staple food income, include (1) horticultural farming experience, (2) extension and (3) farmer field schools related to horticultural crops. Previous literature showed that experience, information from extension and training (knowledge) are important factors in farmer adoption (diversification) decisions (Doss 2006; Feder, Just & Zilberman 1985; Ibrahim et al. 2009; Knowler & Bradshaw 2007). In Indonesia, there is a specific training program related to horticultural crops, namely Farmer Field School-Good Agricultural Practices/Good Handling Practices (FFS-GAP/GHP). This means that specific experiences, information and knowledge related to horticultural crop production are important factors of farmer decisions to diversify production towards horticultural crops. Therefore, these variables as instruments are expected to be correlated with horticultural crop diversification and not expected to directly affect farm household staple food supply and income.

The second group of instruments correlating to horticultural crop diversification, but not related to horticultural food production (or horticultural income), include (1) extension, (2) farmer field school related to staple food crops, and (3) grain mill ownership. The motivation behind using these instruments is the same as explained above for extension and farmer field school for horticultural crops. The Indonesian Government conducted specific training programs for farmers related to staple food crops, namely Farmer Field School-Integrated Crop Management (FFS-ICM)[26]. Another motivation is that agricultural machinery ownership influences farmer decisions to diversify production

[26] The study labelled *Sekolah Lapang Pengelolaan Tanaman Terpadu (SL-PTT) in Indonesian (Bahasa)*. There are three different *SL-PTT* for three different staple food crops which are for rice (*SL-PTT Padi*), maize (*SL-PTT Jagung*) and soybean (*SL-PTT Kedele*).

systems (Mesfin, Fufa & Haji 2011). In this study context, extension and FFS to staple crops and grain mill ownership are expected to affect horticultural crop diversification and not expected to affect horticultural crop production or horticultural income. The latter instrument correlating to horticultural crop diversification, but not related to estate crop production, is extension designed to estate crops, such as sugarcane.

7.3 Results and Discussion

In this section regression results are discussed starting with results on descriptive statistics of key variables, then moving to results on farm household food production and farm household income. Full estimation results for the six systems of equations are shown in the Appendices 8-13.

7.3.1 Descriptive Results

The summary statistics for the dependent and independent variables estimated in the regression model, presented in Table 7.1, show that farmers diversifying in horticultural crops farmed more land, had less family labour available to them and were located further from urban markets than non-horticultural farmers. The most common vegetables produced by Indonesian farmers in 2011/2012 were chillies, cucumber, shallots and tomatoes. The most common fruits produced were banana, *rambutan*, snake fruits, mangoesteen, and watermelon. The detailed crops produced and farm land allocated for agricultural production by Indonesian farmers in 2011/2012 is presented in the Appendices 6 and 7.

Table 7.1. Summary statistics for dependent and independent variables

	All Samples	Non-Horticultural farmers	Horticultural farmers	Diff
Age HH (years)	51.71	52.11	51.10	1.01
	(11.22)	(11.34)	(11.01)	
Education HH (years)	7.20	7.09	7.37	-0.27
	(3.41)	(3.49)	(3.27)	
Number of adult aged between 16-65	2.69	2.76	2.58	0.18***
	(1.06)	(1.10)	(0.99)	
Mobile phone ownership (unit)	1.83	1.79	1.90	-0.11
	(1.29)	(1.21)	(1.39)	
Transportation asset (million Rp)	8.42	9.09	7.42	1.67
	(20.27)	(23.85)	(12.68)	
Production asset (million Rp)	1.49	1.59	1.34	0.25
	(3.95)	(4.13)	(3.65)	
Storage asset (million Rp)	2.06	1.35	3.13	-1.77
	(19.00)	(9.58)	(27.72)	
Farm size (ha)	0.76	0.69	0.88	-0.19***
	(0.77)	(0.69)	(0.85)	
% of rented land	13.58	12.77	14.82	-2.01
	(29.86)	(29.27)	(30.74)	
% of irrigated land	56.25	66.25	41.10	25.15***
	(43.81)	(43.19)	(40.30)	
Remittance income (million Rp)	1.35	1.74	0.76	0.98
	(13.69)	(17.45)	(3.12	
Pension income (million Rp)	0.51	0.43	0.62	-0.19
	(3.77)	(3.37)	(4.32)	
Distance to nearest urban market (km)	20.55	18.79	23.21	-4.43***
	(13.59)	(12.68)	(14.22)	
Elevation (m)	196.25	145.71	272.92	-127.22***
	(295.11)	(259.65)	(327.73)	
Member in farmer group (1/0)	0.78	0.77	0.80	-0.03
	(0.42)	(0.42)	(0.40)	
Horticultural farming experience (1/0)	0.40	0.08	0.88	-0.81***
	(0.49)	(0.27)	(0.32)	
Number of observations	959	578	381	

Notes: Mean values are shown with standard deviation in parentheses. Mean values between horticultural farmers and non-horticultural farmers were tested for statistically significant difference. Based on t-test: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

7.3.2 Value of Food Production Effects

Horticultural diversification has a positive and significant effect on horticultural supply (Table 7.2, Column 1). This effect is relatively large. An increase in the area under horticultural crop production by 10% increases total value of horticultural crops by almost IDR 12 million per hectare. This large effect is expected as horticultural crops are a higher value agricultural product.

Horticultural diversification also has a negative and significant effect on value of staple food production per hectare (Table 7.2, Column 2). When farm households increase diversification into horticultural crop production by 1%, they lose 0.3 million rupiah worth of staple food production. However, the net effects of horticultural diversification on agricultural production are positive and significant, as shown in Table 7.2, Column 5. This means that although horticultural diversification results in the loss of 0.6 million rupiah from staples, estate crops, and wage income, a gain of 1.3 million rupiah outweighs the losses for a net effect of 0.6 million rupiah.

Disaggregating the results by lowland and highland zones, Table 7.2 shows that horticultural diversification has a positive and significant effect on horticultural supply in both lowland areas and highland areas. On the other hand, horticultural crop diversification has a negative and significant effect on staple food supply only in lowland areas. This suggests that staple food supply is largely lost when farm households expand horticultural production in lowland areas. Observations during the survey indicated that higher value horticultural products, such as chillies, shallots, melon, and watermelon, are produced in lowland areas, such as in Demak and Jombang. For policy makers, these trade-offs should be considered when promoting horticultural production in a lowland area, particularly in areas suitable for staple food crops.

The overall effect of horticultural diversification on agricultural supply is positive, both in lowland and highland areas (Table 7.2, Columns 5 and 6). However, horticultural diversification has a significant effect only on agricultural supply in highland areas. This suggests that by diversifying more toward horticultural crops, farm households in highland areas gain higher benefits than farm households in the lowlands. These differences can be partly explained highland areas favouring horticultural crop production in terms of agro-ecological conditions.

Table 7.2. Effects of horticultural crop diversification on the value of food supply

	Value of horticultural crops per ha (million IDR/ha)	Value of staple crops per ha (million IDR/ha)	Value of estate crops per ha (million IDR/ha)	Wage income per ha (million IDR/ha)	Net effect on agricultural output per ha (million IDR/ha)	Total net effect (million IDR/ha)
	(1)	(2)	(3)	(4)	(5)	(6)
All sample (n=959)						
Diversification	1.284***	-0.314***	-0.105	-0.217	0.865***	0.648**
	(0.264)	(0.062)	(0.064)	(0.132)		
Low land (n=690)						
Diversification	0.978**	-0.365***	-0.218***	-0.311**	0.394	0.083
	(0.478)	(0.065)	(0.057)	(0.152)		
High land (n=269)						
Diversification	0.865***	-0.181	0.031	0.069	0.715**	0.784*
	(0.268)	(0.148)	(0.143)	(0.279)		

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All control variables included in the regressions is presented shown in the Appendices 8-10. IDR = Indonesian Rupiah

7.3.3 Income Effects

As expected, horticultural crop diversification has a positive and significant effect on horticultural income (Table 7.3, Column 2). Horticultural crop diversification has the expected negative and significant effect on agricultural income from staple food crops. However, the staple income effect is relatively smaller than horticultural income effect. While an increase in the share of horticultural crop area by 1% increases horticultural income by 0.4 million rupiah per hectare, it affects staple food income loss by almost 0.2 million rupiah per hectare.

The net agricultural income effect, on average, is positive but is not statistically significant (Table 7.3, Column 5). Results also suggest that farm household net income effect of horticultural crop diversification is relatively small (Table 7.3, Column 6). This result is in line with descriptive statistics that show no significant different farm household income between adopters of new horticultural crops and non-adopters, as presented in Chapter 4.

The result is also in line with a recent study by Narayanan (2014) and another study by Hernández, Reardon and Berdegué (2007), both of which show participation in higher value agricultural chains may partly be associated with higher profit. However, this result is somewhat surprising considering previous studies have shown that participation in higher value horticultural chains is often associated with higher household income (e.g. Miyata, Minot & Hu 2009; Rao & Qaim 2011; Sahara et al. 2015).

There are three possible explanations for the results. First, while other studies examined farmers with links to modern markets (e.g. supermarkets, processors), this study examined farmers, who in general are not specifically linking to modern markets. In other words, farmer participation in high value horticultural chains may be constrained by lack of market access (Pingali 2015; Zakaria et al. 2015). Second, recent research by Zakaria et al. (2015) suggests that Indonesian horticultural farmers could not receive maximum profit as they are still largely using traditional technologies, such as a low quality seed. Another plausible explanation is that horticultural crops are more knowledge and capital intensive than staple crops (Birthal et al. 2013; Joshi, Joshi & Birthal 2006; Lumpkin, Weinberger & Moore 2005). This means that entering horticultural production involves higher costs, particularly start-up costs, and time to learn and use different production techniques.

Hence, greater input costs of horticultural crop production means that profit from horticultural crops is roughly similar to profit from non-horticultural crops.

In regard to farm income effect by lowland and highland zones, this study shows that horticultural diversification has a negative and significant effect on farm household agricultural income (from staple food crops and estate crops) and wage income in lowland areas (Table 7.3, Columns 2-4). This means there is a significant trade-off between horticultural diversification and agricultural income from non-horticultural crops in lowland areas. In addition, expansion of horticultural crops also has significant association with lower wage income in lowland areas. For policy makers, these trade-offs may be a consideration when promoting horticultural crop production in lowland areas.

Overall, horticultural diversification had a high positive impact on agricultural incomes in highland areas (Table 7.3, Column 5). However, those overall effects in lowland and highland areas are not statistically significant (Table 7.3, Columns 5 and 6).

Table 7.3. Effects of horticultural crop diversification on agricultural income

	Horticultural income per ha (million IDR/ha)	Staple crop income per ha (million IDR/ha)	Estate crop income per ha (million IDR/ha)	Wage income per ha (million IDR/ha)	Net effect on agricultural income per ha (million IDR/ha)	Total Net Effect (million IDR/ha)
	(1)	(2)	(3)	(4)	(5)	(6)
All sample (n=959)						
Diversification	0.419**	-0.180***	-0.032	-0.217	0.207	-0.009
	(0.163)	(0.047)	(0.060)	(0.132)		
Low land (n=690)						
Diversification	0.302	-0.213***	-0.125***	-0.311**	-0.036	-0.351
	(0.336)	(0.051)	(0.046)	(0.152)		
High land (n=269)						
Diversification	0.165	-0.076	0.033	0.069	0.058	0.127
	(0.177)	(0.106)	(0.142)	(0.279)		

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All control variables included in the regressions is presented shown in the Appendices 11-13. IDR = Indonesian Rupiah

7.3.4 Identifying Conditions

As described in Section 7.2.2, the variable *Diversification*$_i$ may potentially be endogenous in equation (7.1). To test whether endogeneity is an issue leading to a bias in estimation, this study used instrumental variables. In this section, statistical results from the first stage equation for these instruments are described. Full estimation of the first stage results for the six systems of equations are presented in the Appendix 14.

Results of the first stage coefficients on five instrumental variables for food supply and income equations indicate a statitistically significant relationship with the *Diversification*$_{i,}$ variable. For example, *Horticultural farming experience*$_D$ and *Extension for horticultural production*$_D$ have a positive and significant relationship with the *Diversification*$_{i,}$ variable. This suggests that the instrumental variables are valid and have reasonable explanatory power in the first stage. As expected, experienced horticultural farming households and households who received government programs related to horticultural production were more likely to diversify their production system to include horticulture crops.

In addition to the requirement that instrumental variables be correlated with endogenous regressors, the instruments must also be uncorrelated with the structural error term. As the models in this study are over-identified, meaning that the number of instrument variables exceeds the number of endogenous variables, a test of over-identifying restrictions was performed (Baum, Schaffer & Stillman 2003). Tests of over-identifying restrictions report Sargan's (1958) and Basmann's (1960) chi2 tests. In this study, the results, Sargan chi2(3) = 3.18 and Basmann chi2(3) = 3.11, showed that both test statistics are insignificant at the 1% test level, which means that the study instruments are valid or that structural models for horticultural supply are specified correctly. Similarly, both test statistics for staple food supply and estate crop supply equations are insignificant at the 1% level, with results of Sargan chi2(3) = 3.99 and Basmann chi2(3) = 3.91, and Sargan chi2(3) = 8.67 and Basmann chi2(3) = 8.54, respectively.

The significance of instruments in first stage regressions together with tests of over-identifying restrictions demonstrates that the instrument variables are valid. Therefore, the instrument proposed satisfies the relevance condition.

7.4 Conclusions

This thesis chapter examined the relationship between horticultural crop diversification and measures of livelihoods, food supply and agricultural income, disaggregated into three groups: horticulture, staple food and estate crops. This is the first study in agricultural economics literature to measure the trade-offs between horticultural crop diversification and staple food crop supply. While other studies examined the impact of agricultural diversification at the aggregate level as explained in Chapter 2, this study is makes an important contribution to the literature as it examined, at the smallholder farmer level, the specific impact of horticultural crop diversification on farm household staple food production and income. Therefore, this study could help Indonesian policy makers better support smallholder farmer participation in Indonesia's higher value horticultural chains.

This chapter presented evidence that horticultural crop diversification decreases the value of non-horticultural crop supply and wage income, particularly in lowland areas, but the net effect is positive and small (0.65 million rupiah). Even though the net effect on total value of food supply is higher in highland areas, it is important to note that the income effect is small. This is an interesting result compared to previous studies on crop diversification, which found significant and positive impacts on household income (e.g. Ibrahim et al. 2009; Pellegrini & Tasciotti 2014; Sichoongwe et al. 2014), but these studies did not specifically examine horticultural crop diversification. Another plausible reason is that the Indonesian farmers in this study, who are diversified in horticultural crop production, may still lack access to profitable markets. Other studies, for example by Narrod et al. (2009) and Roy and Thorat (2008) in India and by Schipmann and Qaim (2009) in Thailand showed that smallholder farmers can benefit when they are linked to profitable horticultural markets such as supermarkets or export markets through institutional arrangements such as public private partnership or collective action. Therefore, developing institutional arrangements may be needed to promote greater participation of Indonesian smallholder farmers in horticultural value chains.

Study findings inform the impacts of self-sufficiency policy on the value of food production lost by expanding horticultural production. Given the importance of agricultural policy beyond staple foods (see Pingali 2015; Reardon et al. 2015), it is likely that policies encouraging development of horticultural production systems are still needed. Therefore, targeting horticultural extension and training programs, including in lowland areas, may be considered when farm households are located in the Indonesia's horticultural development region (*pengembangan kawasan agribisnis hortikultura - PKAH*[27]), which have greater access to the horticultural markets.

The limitations of this study should be considered, particularly when interpreting the results for policy analysis. In contrast to previous studies, the results of this study were obtained from a survey that has two broad views of agricultural sectors, which are not addressed specifically to high value horticultural crops and horticultural production zone. Other studies focus on income effects from adoption of a novel agricultural technology or crop variety, while this study looks at shifts in production systems. A small or null effect in

[27] PKAH programs is one of the six horticultural development pillars enacted by the Indonesian Ministry of Agriculture. The programs aim to systemise farm operations and increase efficiency of distribution while developing plantations and providing technical assistance for horticultural production, particularly in un-irrigated areas of Indonesia. The programs also involve development of basic infrastructure for horticultural crop production and provision of resources and training in propagation techniques. Examples of PKAH are PKAH mangoes in Cirebon, West Java, PKAH chillies in Ciamis, West Java and PKAH citrus in Tuban East Java.

this study may indicate that crop choices are, in aggregate, produced rather efficiently with respect to income. Hence, further studies are needed to better understand the conditions required to help smallholder farmers diversify successfully towards high value horticultural crops to improve their livelihood.

8 Chapter Eight: Summary, Conclusions and Implications

8.1 Summary and Conclusions

Indonesia is experiencing an agricultural food market transformation, with rapidly growing demand for high value commodities, including horticultural products such as fruits and vegetables. Given this rapid transformation, promoting smallholder farmer participation in higher value horticultural chains to improve their livelihoods has become an important policy recommendation. However, Indonesian smallholder farmers' participation in horticultural value chains remains low. These low participation rates are puzzling considering the long history of agricultural extension programs encouraging adoption of new horticultural crops. Low participation rates raise concerns regarding whether Indonesian smallholder farmers are constrained from diversifying their production systems into horticultural crops. Therefore, one of the important objectives of this thesis was to examine the various factors that may play a role in determining whether or not Indonesian farmers adopt new horticultural crops.

In addition to having some programs to support increasing production of certain horticultural crops, the GoI prioritises self-sufficiency in staple food crops, such as rice, maize and soybean. Given this policy, there is concern regarding whether Indonesian smallholder farmers will forego the benefits of the agricultural food market transformation which presents new market opportunities for farmers willing to diversify their production to include more potentially profitable non-traditional, high value horticultural crops (Reardon et al. 2009).

There are also questions about whether promoting diversification towards horticultural crops, such as fruits and vegetables, will detract from the important priority of staple food security in Indonesia. Despite the importance of this issue, there is little evidence for such implications of horticultural crop diversification in Indonesia. Therefore, another objective of this thesis was to examine the impact of horticultural crop diversification on farm household food supply and income.

The main contributions of this thesis are two-fold. First, it provides a methodological contribution to empirical studies on farmer perceptions of agricultural technology attributes and determinant factors of agricultural technology adoption in developing countries. Second, it provides information of interest to policy makers regarding possible implications of horticultural crop diversification on farm household food supply and income in developing countries.

This study had four specific objectives. The first objective, addressed in Chapter 4, was to describe current practices of horticultural crop adoption in Indonesia and to identify different characteristics between adopting and non-adopting farmers with respect to household, production and marketing characteristics. The second objective, addressed in Chapter 5, was to analyse which crop attributes Indonesian farmers prefer when considering adoption of a new crop and to examine the heterogeneity in Indonesian farmer preferences for crop attributes. The third objective, addressed in Chapter 6, was to examine determinant factors in adopting high value horticultural crops, particularly the effects of farmer preferences for specific technology attributes in adoption decisions. The fourth objective, addressed in Chapter 7, was to analyse the impact of farmer adoption of high value crops on farm household food supply and income.

In order to achieve the study objectives, data was obtained through a comprehensive survey of 960 farm households that produce a variety of agricultural crops in six districts on Java Island, Indonesia. Farm households were chosen using a stratified random sampling method. To capture farm households engaged in horticultural crop production, this study used distance to major cities as proxy for markets, and elevation (agro-ecological zones) for stratification. Eighteen experienced and trained enumerators interviewed 960 farm households from February to March 2013. Survey data was used to undertake four different analyses with the intention of addressing the four main objectives of this study.

The first analysis, presented in Chapter 4, described the current status of horticultural crop adoption in Indonesia and highlighted the characteristics of farmers who adopted and those who did not adopt a new horticultural crop with respect to the household (farmer), farm and institutional characteristics. Basic statistical analysis showed relatively low adoption rates (10%) of new horticultural crops amongst 960 selected Indonesian farmers with different decisions made in terms of number and timing of new horticultural crop adoption. New horticultural crop adoption includes a shift from one horticultural crop to another and from staple crops to horticultural crops. Adopters were motivated mainly by higher profit, higher yield and more cash opportunities. These reasons could be indicative of attitudes towards horticultural crop attributes that adopters expect from adoption. Results of basic descriptive statistics also showed that non-adopters were relatively older, less educated, had less access to mobile phones and the Internet, and were less diversified in their farming systems. They also lacked information and training about horticultural crop production. In addition, results showed that many non-adopters were generally not participating in producer organisations, such as a farmer group or cooperative.

The second analysis, presented in Chapter 5, addressed Indonesian farmer preferences for specific crop attributes when considering adopting a new crop. This chapter also addressed farmer heterogeneity in preferences for crop attributes at the group (segment) level. Best-worst scaling analysis showed that the three most important crop attributes for average Indonesian farmers are related to: (1) relative advantage of a new crop such as higher expected profit, (2) risk such as stable and consistent yield and (3) provision of inputs such as good quality seed. Latent class (LC) cluster analysis identified four distinct clusters of farmers: program dependent farmers (the largest), profit maximisers, risk-averse farmers and input minimisers. Each cluster showed unique utilities for crop attributes, which highlight the different sets of needs of farmer clusters when making decisions to adopt a new crop. Each cluster also had distinct socio-demographic characteristics that may provide insight into why a specific cluster of farmers perceive relatively greater or lower importance regarding certain crop attributes.

The third analysis, presented in Chapter 6, integrated findings presented in Chapter 5 by examining determinant factors in horticultural crop adoption, particularly the effect of farmer preferences for crop attributes on horticultural crop adoption. Potential endogeneity of farmer preferences for crop attributes was addressed using a multinomial endogenous treatment model. After controlling for other factors, multinomial endogenous treatment regressions showed that preference cluster effect varied across models. Product-preference cluster had no significant effect on adoption measured as a binary variable, that is adopt or not adopt. However, the product-preference cluster did have a significant effect on intensity of adoption and timing of adoption. This study proposes that examining the effect of farmer preferences for crop attributes is important in understanding the adoption process.

The fourth analysis, presented in Chapter 7, addressed the fourth thesis objective "to analyse the impact of farmer adoption of horticultural crops on farm household food supply and income, rather than staple crops as encouraged by the Indonesian government". This analysis addressed trade-offs between horticultural crop diversification and staple food crop supply. Simultaneous equations regressions, a three-stage least square (3SLS) estimation, found evidence that horticultural crop diversification decreases value of non-horticultural crop supply and wage income, particularly in lowland areas, but the net effect is positive. Even though the net effect on total value of food supply is higher in highland areas, it is important to note that the income effect is small. The findings inform self-sufficiency policy on the value of food supply lost by expanding horticultural production.

8.2 Policy Implications

Four main policy implications resulting from this study are worthy of further discussion. **First,** Indonesian smallholder farmers have an opportunity to respond to the rapid growth of high value horticultural market by adopting new horticultural crops such as fruits and vegetables. However, study results indicated that adoption rates of these crops remains low despite existing promotion of horticultural crop production in Indonesia by the government and NGOs. Results also suggest that low adoption rates may be caused by a variety of factors, such as low levels of education amongst farmers, resources constraints, lack of information on horticultural crop production and low participation in farmer groups. Study findings show that Indonesian farmers face adoption constraints regarding horticultural crops. Therefore, more intensive support is needed to promote greater participation of Indonesian smallholder farmers in horticultural value chains. In other words, a revitalisation of agricultural policy beyond staple food is important (Pingali 2015; Reardon et al. 2015) to seize potential benefits from the ongoing agricultural food market transformation.

Second, study results indicate that farmer attitudes towards technology (crop) attributes play an important role in horticultural crop adoption. Access to key resources as perceived by farmers, such as good quality seeds and training, should be improved to encourage continued adoption. This implies that, in Indonesia, policy makers may consider the role of farmer perceptions in farmer decision-making related to the decision to adopt new crops. This can be achieved, for example, by enhancing communication between agricultural extension agents and farmers to potentially improve efficiency in adoption promotion. Such information is of great importance in assisting policy makers and public/private funders to effectively allocate investments in agricultural research in the future. It is also necessary for empirical studies to pay careful attention to farmer perceptions in modelling agricultural technology adoption. The omission of this attitudinal variable could bias estimation results.

Third, while some farmers have the potential to successfully diversify into horticulture, others may not. Therefore, Indonesian policy makers may consider targeting groups of farmers rather than all farmers to effectively expand horticultural crop production. In other words, not all programming and policy works similarly for all farm households. This study produced an understanding of which groups of farmers should be targeted in promotion of horticultural crops. Results indicate that heterogeneity in perceptions of crop attributes exists amongst groups of farmers. Specifically, targeting farmers in the *risk-averse cluster* may be a better strategy to promote horticultural development in Indonesia as these farm households tend to be younger and have more agricultural assets, but are also relatively slow to adopt new horticultural crops. Hence, horticultural development programming may be more effective by using tailored strategies to support this group of farmers to adopt earlier. Targeting this cluster to diversify towards horticulture is also consistent with recommendations of a report by IFPRI (2015) suggesting that policy makers should support farmers in *moving up* to more profitable farming activities.

Study results also show that farmers in highland areas[28] should be targeted for horticultural crop expansion as horticultural diversification has a significant effect on agricultural supply in highland areas due to favourable agro-ecological conditions. Another result is that staple food supply is largely lost when households expand horticultural production in lowland areas. Therefore, policy makers may consider this trade-off when

[28] It is important to note that highland regions in this study include medium elevation (200-600m) and high elevation (>600m).

promoting horticultural production in a lowland area, particularly in areas suitable for staple food crops, such as rice, maize and soybean. However, targeting horticultural extension and training programs may consider lowland areas specifically located in Indonesia's horticultural development regions (*PKAH*) as targeted areas for greater horticultural production in Indonesia. Horticultural expansion in the lowland areas could also consider extending beyond Java to develop new and emerging production zones for priority horticultural crops (*komoditas unggulan*), such as shallots in Minahasa North Sulawesi and Bima West Timor, chilies in Gorontalo and West Sumatra (MOA 2014b). This equal policy is needed to develop sound domestic food policy for strong horticultural production development allowing economic benefits to farmers and to ensure national food self-sufficiency based on staple food crops.

Fourth, this study showed that the income effect of horticultural diversification is minor suggesting that encouraging smallholder farmers to diversify production systems to include new horticultural crop adoption may not be sufficient to improve farm household income. Horticultural crops with relatively high costs of production should be carefully considered by smallholder farmers, particularly farmers lacking experience producing horticultural crops. Promotion of horticultural crop production is not a substitute but a complementary strategy to growing staple food crops as horticultural crops are essentially a means of enabling smallholder farmers to diversify into higher risk business areas. In addition, Indonesian smallholder farmers need to be encouraged to produce higher value horticultural crops rather than lower value horticultural crops.

For potential benefits of horticultural crop production to be achieved by smallholder farmers, strategies need to be implemented in a consultative manner, particularly in research, infrastructure, and institutional developments (Kabunga, Ghosh & Griffiths 2014; Reardon et al. 2015). Further research needs to focus on identifying which horticultural crops to include as higher value crops and examine the efficiency of horticultural diversification in terms of production or input use. The Government of Indonesia may also want to consider investing in the public infrastructure required to promote efficient supply chains for perishable horticultural products. According to Reardon et al. (2015), this includes investing in water control, road and electricity infrastructure, training by extension agents, communication and wholesale market infrastructure. Another strategy is that policy makers need to develop institutional innovations to profitably link smallholder farmers to appropriate markets as this is critical to growth of horticultural crops.

Benefitting from high value horticultural crops is about more than production (diversification or adoption) and is inclusive of improving smallholder access to markets. For example, through institutional arrangements, smallholder farmers may be able to participate in the new modern market channels, which offer the opportunities to get higher income (Narrod et al. 2009; Sahara et al. 2015; Schipmann & Qaim 2009). Therefore, further research is required to identify the market types that should be considered in horticultural crop development for smallholder farmers whether local, national or export markets.

Another important result of this study is the finding that horticultural crop expansion, rather than exclusive focus on staple food crops, provides greater supply of agricultural products measured by value of production, particularly in terms of horticultural supply. This suggests that horticultural diversification offers greater micronutrient-based foods rich in vitamin and minerals to farm households and consumers. This is beyond the analysis presented in this study, but provides an interesting starting point for further, more interdisciplinary research.

Although the results of this study are based on primary data from a large-scale survey and rigorous econometric tools, there are two limitations. First, this study used cross-sectional data. Although panel data provide the most suitable data set to capture the dynamics of adoption (Doss 2006), data collection can be extremely resource-demanding and such data are therefore rarely available. Second, this study focused on farm households on Java Island. Further research may be extended outside Java considering the growing market for horticultural crops. Future research may also address differences in specific conditions including those related to agro-ecological zones, coupled with difference in specific market institutions, to achieve a better understanding of differences in findings across studies.

References

Abdi, H & Williams, LJ 2010, ‘Tukey’s honestly significant difference (HSD) test’, *Encyclopedia of Research Design, Thousand Oaks, CA: Sage*, pp. 1-5.

Abdollahzadeh, G, Sharifzadeh, MS & Damalas, CA 2015, 'Perceptions of the beneficial and harmful effects of pesticides among Iranian rice farmers influence the adoption of biological control', *Crop Protection*, vol. 75, pp. 124-131.

Abebaw, D & Haile, MG 2013, 'The impact of cooperatives on agricultural technology adoption: Empirical evidence from Ethiopia', *Food Policy*, vol. 38, pp. 82-91.

ADB 2013, *Asia’s economic transformation: Where to, how, and how fast?*, Key indicators for Asia and the pacific 2013 special chapter, Asian Development Bank, Mandaluyong City, Philippines.

Adesina, AA & Baidu-Forson, J 1995, 'Farmers' perceptions and adoption of new agricultural technology: Evidence from analysis in Burkina Faso and Guinea, West Africa', *Agricultural Economics*, vol. 13, no. 1, pp. 1-9.

Adesina, AA, Mbila, D, Nkamleu, GB & Endamana, D 2000, 'Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of Southwest Cameroon', *Agriculture, Ecosystems & Environment*, vol. 80, no. 3, pp. 255-265.

Adesina, AA & Zinnah, MM 1993, 'Technology characteristics, farmers' perceptions and adoption decisions: A tobit model application in Sierra Leone', *Agricultural Economics*, vol. 9, no. 4, pp. 297-311.

Ainembabazi, JH & Mugisha, J 2014, 'The role of farming experience on the adoption of agricultural technologies: Evidence from smallholder farmers in Uganda', *Journal of Development Studies*, vol. 50, no. 5, pp. 666-679.

Ajzen, I 1991, 'The theory of planned behavior', *Organizational Behavior and Human Decision Processes*, vol. 50, no. 2, pp. 179-211.

Ali, M & Tsou, SC 1997, 'Combating micronutrient deficiencies through vegetables: A neglected food frontier in Asia', *Food Policy*, vol. 22, no. 1, pp. 17-38.

Asfaw, S, Shiferaw, B, Simtowe, F & Lipper, L 2012, 'Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia', *Food Policy*, vol. 37, no. 3, pp. 283-295.

Asrat, S, Yesuf, M, Carlsson, F & Wale, E 2010, 'Farmers' preferences for crop variety traits: Lessons for on-farm conservation and technology adoption', *Ecological Economics*, vol. 69, no. 12, pp. 2394-2401.

Auger, P, Devinney, TM & Louviere, JJ 2007, 'Using best-worst scaling methodology to investigate consumer ethical beliefs across countries', *Journal of Business Ethics*, vol. 70, no. 3, pp. 299-326.

Babatunde, RO & Qaim, M 2010, 'Impact of off-farm income on food security and nutrition in Nigeria', *Food Policy*, vol. 35, no. 4, pp. 303-311.

Balcombe, P, Rigby, D & Azapagic, A 2014, 'Investigating the importance of motivations and barriers related to microgeneration uptake in the UK', *Applied Energy*, vol. 130, pp. 403-418.

Barghouti, S, Kane, S, Sorby, K & Ali, M 2004, 'Diversification for the poor', Agriculture and Rural Development Discussion Paper 1, Washington, DC.

Barham, BL, Chavas, JP, Fitz, D, Salas, VR & Schechter, L 2014, 'The roles of risk and ambiguity in technology adoption', *Journal of Economic Behavior & Organization*, vol. 97, pp. 204-218.

Barrett, CB, Bachke, ME, Bellemare, MF, Michelson, HC, Narayanan, S & Walker, TF 2012, 'Smallholder participation in contract farming: Comparative evidence from five countries', *World Development*, vol. 40, no. 4, pp. 715-730.

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.

Basu, AK & Qaim, M 2007, 'On the adoption of genetically modified seeds in developing countries and the optimal types of government intervention', *American Journal of Agricultural Economics*, vol. 89, no. 3, pp. 784-804.

Basuki, R, Adiyoga, W & Gunadi, N 2008, 'Impact of improved vegetable farming technology on farmers' livelihoods in Indonesia', in *International Symposium on the Socio-Economic Impact of Modern Vegetable Production Technology in Tropical Asia 809,* pp. 101-112.

Batz, FJ, Peters, KJ & Janssen, W 1999, 'The influence of technology characteristics on the rate and speed of adoption', *Agricultural Economics*, vol. 21, no. 2, pp. 121-130.

Baum, CF, Schaffer, ME & Stillman, S 2003, 'Instrumental variables and GMM: Estimation and testing', *Stata Journal*, vol. 3, no. 1, pp. 1-31.

Becerril, J & Abdulai, A 2010, 'The impact of improved maize varieties on poverty in Mexico: A propensity score-matching approach', *World Development*, vol. 38, no. 7, pp. 1024-1035.

Bezu, S, Kassie, GT, Shiferaw, B & Ricker-Gilbert, J 2014, 'Impact of improved maize adoption on welfare of farm households in Malawi: A panel data analysis', *World Development*, vol. 59, pp. 120-131.

Birol, E, Villalba, ER & Smale, M 2009, 'Farmer preferences for milpa diversity and genetically modified maize in Mexico: A latent class approach', *Environment and Development Economics*, vol. 14, no. 4, p. 521-540.

Birthal, PS, Joshi, PK, Roy, D & Thorat, A 2013, 'Diversification in Indian agriculture toward high-value crops: The role of small farmers', *Canadian Journal of Agricultural Economics/Revue Canadienne d'agroeconomie*, vol. 61, no. 1, pp. 61-91.

Birthal, PS, Roy, D & Negi, DS 2015, 'Assessing the impact of crop diversification on farm poverty in India', *World Development*, vol. 72, pp. 70-92.

Black, K 2009, *Business statistics: Contemporary decision making*, John Wiley & Sons.

Boxall, PC & Adamowicz, WL 2002, 'Understanding heterogeneous preferences in random utility models: A latent class approach', *Environmental and Resource Economics*, vol. 23, no. 4, pp. 421-446.

BPS 2013, *Laporan hasil sensus pertanian 2013 (report of the national agricultural census 2013)*, Badan Pusat Statistik, Jakarta.

BPS 2014, 'Hortikultura: Produksi buah-buahan menurut provinsi 2012', <http://www.bps.go.id/tab_sub/view.php?kat=3&tabel=1&daftar=1&id_subyek=55&notab=11>.

Breetz, HL, Fisher-Vanden, K, Jacobs, H & Schary, C 2005, 'Trust and communication: mechanisms for increasing farmers' participation in water quality trading', *Land Economics*, vol. 81, no. 2, pp. 170-190.

Cohen, E 2009, 'Applying best-worst scaling to wine marketing', *International Journal of Wine Business Research*, vol. 21, no. 1, pp. 8-23.

Cohen, S & Orme, B 2004, 'What's your preference? Asking survey respondents about their preferences creates new scaling decisions', *Marketing Research*, vol. 16, pp. 32-37.

Crost, B, Shankar, B, Bennett, R & Morse, S 2007, 'Bias from farmer self-selection in genetically modified crop productivity estimates: Evidence from Indian data', *Journal of Agricultural Economics*, vol. 58, no. 1, pp. 24-36.

Cunguara, B & Darnhofer, I 2011, 'Assessing the impact of improved agricultural technologies on household income in rural Mozambique', *Food Policy*, vol. 36, pp. 378-390.

Daryanto, A, Fahmi, I, Achsani, NA, Asmara, A, Yuwono, M, Asnawi, YH & Suhendi 2015, *Transformasi struktural usahatani dan petani Indonesia*, Analisis tematik ST2013 subsektor, Badan Pusat Statistik, Jakarta.

Deb, P & Trivedi, PK 2006a, 'Maximum simulated likelihood estimation of a negative binomial regression model with multinomial endogenous treatment', *The Stata Journal*, vol. 6, no. 2, pp. 246-255.

Deb, P & Trivedi, PK 2006b, 'Specification and simulated likelihood estimation of a non-normal treatment-outcome model with selection: Application to health care utilization', *The Econometrics Journal*, vol. 9, no. 2, pp. 307-331.

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

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

Edmeades, S, Phaneuf, DJ, Smale, M & Renkow, M 2008, 'Modelling the crop variety demand of semi-subsistence households: Bananas in Uganda', *Journal of Agricultural Economics*, vol. 59, no. 2, pp. 329-349.

FAOSTAT 2014, 'Trade: Crops and livestock products', <http://faostat3.fao.org/faostat-gateway/go/to/browse/T/TP/E>.

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.

Finn, A & Louviere, JJ 1992, 'Determining the appropriate response to evidence of public concern: The case of food safety', *Journal of Public Policy and Marketing*, vol. 11, no. 2, pp. 12-25.

Fisher, M & Kandiwa, V 2014, 'Can agricultural input subsidies reduce the gender gap in modern maize adoption? Evidence from Malawi', *Food Policy*, vol. 45, pp. 101-111.

Fliegel, FC & Kivlin, JE 1966, 'Attributes of innovations as factors in diffusion', *American Journal of Sociology*, vol. 72, no. 3, pp. 235-248.

Flynn, TN, Louviere, JJ, Peters, TJ & Coast, J 2007, 'Best-worst scaling: What it can do for health care research and how to do it', *Journal of Health Economics*, vol. 26, no. 1, pp. 171-189.

Foster, AD & Rosenzweig, MR 2010, 'Microeconomics of technology adoption', *Annual Review of Economics*, vol. 2, Sep 1.

Ghimire, R & Huang, W-C 2015, 'Household wealth and adoption of improved maize varieties in Nepal: A double-hurdle approach', *Food Security*, vol. 7, no. 6, pp. 1321-1335.

Greene, W 2003, 'Econometric Analysis', 5th ed. New York: Prentice-Hall International.

Hernández, R, Reardon, T & Berdegué, J 2007, 'Supermarkets, wholesalers, and tomato growers in Guatemala', *Agricultural Economics*, vol. 36, no. 3, pp. 281-290.

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.

Hichaambwa, M, Chamberlin, J & Kabwe, S 2015, *Is smallholder horticulture the unfunded poverty reduction option in Zambia? A comparative assessment of welfare effects of participation in horticultural and maize markets*, Citeseer.

Hintze, LH, Renkow, M & Sain, G 2003, 'Variety characteristics and maize adoption in Honduras', *Agricultural Economics*, vol. 29, pp. 307–317.

Hossain, ST, Sugimoto, H, Ueno, H & Huque, SMR 2007, 'Adoption of organic rice for sustainable development in Bangladesh', *Journal of Organic Systems*, vol. 2, no. 2, pp. 27-37.

Hughes, JdA & Keatinge, J 2012, 'The nourished millennium: How vegetables put global goals for healthy, balanced diets within reach', in R Holmer, G Linwattana, P Nath & J Keatinge (eds), *High Value Vegetables in Southeast Asia: Production, Supply and Demand (SEAVEG2012),* AVRDC-The World Vegetable Center, Chiang Mai, Thailand, pp. 11-26.

Ibrahim, H, Rahman, SA, Envulus, EE & Oyewole, SO 2009, 'Income and crop diversification among farming households in a rural area of North Central Nigeria', *Journal of Tropical Agriculture, Food, Environment and Extension*, vol. 8, no. 2, pp. 84-89.

IFPRI 2015, *2014–2015 Global food policy report*, International Food Policy Research Institute, Washington, DC.

Islam, S & Ullah, MR 2012, 'The impacts of crop diversity in the production and economic development in Bangladesh', *International Journal of Economics and Finance*, vol. 4, no. 6, pp. 169-180.

Jack, BK 2011, 'Constraints on the adoption of agricultural technologies in developing countries', *White paper, Agricultural Technology Adoption Initiative, Boston: J-PAL (MIT) and Berkeley: CEGA (UC Berkeley)*.

Jarvis, L & Vera-Toscano, E 2004, 'Seasonal adjustment in a market for female agricultural workers', *American Journal of Agricultural Economics*, vol. 86, no. 1, pp. 254-266.

Joshi, P, Joshi, L & Birthal, PS 2006, 'Diversification and its impact on smallholders: Evidence from a study on vegetable production', *Agricultural Economics Research Review*, vol. 19, no. 2, pp. 219-236.

Kabunga, N, Dubois, T & Qaim, M 2012, 'Heterogeneous information exposure and technology adoption: The case of tissue culture bananas in Kenya', *Agricultural Economics*, vol. 43, no. 5, pp. 473-486.

Kabunga, N, Ghosh, S & Griffiths, JK 2014, 'Can smallholder fruit and vegetable production systems improve household food security and nutritional status of women? Evidence from rural Uganda', IFPRI Discussion Paper 01346.

Kassie, M, Shiferaw, B & Muricho, G 2011, 'Agricultural technology, crop income, and poverty alleviation in Uganda', *World Development*, vol. 39, pp. 1784-1795.

Khonje, M, Manda, J, Alene, AD & Kassie, M 2015, 'Analysis of adoption and impacts of improved maize varieties in Eastern Zambia', *World Development*, vol. 66, pp. 695-706.

Knowler, D & Bradshaw, B 2007, 'Farmers' adoption of conservation agriculture: A review and synthesis of recent research', *Food Policy*, vol. 32, no. 1, pp. 25-48.

Krishnan, P & Patnam, M 2013, 'Neighbors and extension agents in Ethiopia: Who matters more for technology adoption?', *American Journal of Agricultural Economics,* vol. 96, no. 1, pp. 308-327.

Kumar, S & Gupta, S 2015, 'Crop diversification towards high-value crops in India: A state level empirical analysis', *Agricultural Economics Research Review*, vol. 28, no. 2, pp. 339-350.

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

Lagerkvist, CJ, Okello, J & Karanja, N 2012, 'Anchored vs. relative best–worst scaling and latent class vs. hierarchical bayesian analysis of best-worst choice data: Investigating the importance of food quality attributes in a developing country', *Food Quality and Preference*, vol. 25, no. 1, pp. 29-40.

Laksana, S & Damayanti, A 2013, 'Determinants of the adoption of system of rice intensification in Tasikmalaya district, West Java Indonesia', Working Paper in Economics and Development Studies, no. 201306, Bandung.

Lambrecht, I, Vanlauwe, B, Merckx, R & Maertens, M 2014, 'Understanding the process of agricultural technology adoption: Mineral fertilizer in Eastern Dr Congo', *World Development*, vol. 59, pp. 132–146.

Louviere, JJ, Lings, I, Islam, T, Gudergan, S & Flynn, TN 2013, 'An introduction to the application of (case 1) best-worst scaling in marketing research', *International Journal of Research in Marketing*, vol. 30, pp. 292-303.

Louviere, JJ, Flynn, TN & Marley, AAJ 2015, '*Best-worst scaling: Theory, methods and applications*, Cambridge University Press.

Lumpkin, T, Weinberger, K & Moore, S 2005, 'Increasing income through fruit and vegetable production opportunities and challenges', Consultative Group on International Agricultural Research Science Forum CGIAR Priorities: Science for the poor.

Lunduka, R, Fisher, M & Snapp, S 2012, 'Could farmer interest in a diversity of seed attributes explain adoption plateaus for modern maize varieties in Malawi?', *Food Policy*, vol. 37, no. 5, pp. 504-510.

Maertens, M, Minten, B & Swinnen, J 2012, 'Modern food supply chains and development: Evidence from horticulture export sectors in Sub-Saharan Africa', *Development Policy Review*, vol. 30, no. 4, pp. 473-497.

Maertens, A & Barrett, CB 2013, 'Measuring social networks' effects on agricultural technology adoption', *American Journal of Agricultural Economics*, vol. 95, no. 2, pp. 353-359.

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.

Manda, J, Alene, AD, Gardebroek, C, Kassie, M & Tembo, G 2015, 'Adoption and impacts of sustainable sgricultural practices on maize yields and incomes: Evidence from rural Zambia', *Journal of Agricultural Economics,* vol. 67, no. 1, pp. 130-153.

Manning, C 1988, 'Rural employment creation in Java: Lessons from the green revolution and oil boom', *Population and Development Review*, vol. 14, no.1, pp. 47-80.

Mariano, MJ, Villano, R & Fleming, E 2012, 'Factors influencing farmers' adoption of modern rice technologies and good management practices in The Philippines', *Agricultural Systems*, vol. 110, pp. 41-53.

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.

Marra, M, Pannell, DJ & Ghadim, AA 2003, 'The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: Where are we on the learning curve?', *Agricultural Systems*, vol. 75, pp. 215-234.

Mathenge, MK, Smale, M & Olwande, J 2014, 'The impacts of hybrid maize seed on the welfare of farming households in Kenya', *Food Policy*, vol. 44, pp. 262-271.

Matuschke, I & Qaim, M 2009, 'The impact of social networks on hybrid seed adoption in India', *Agricultural Economics*, vol. 40, no. 5, pp. 493-505.

McCulloch, N & Timmer, CP 2008, 'Rice policy in Indonesia: A special issue', *Bulletin of Indonesian Economic Studies*, vol. 44, no. 1, pp. 33-44.

Mendola, M 2007, 'Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh', *Food Policy*, vol. 32, no. 3, pp. 372-393.

Mesfin, W, Fufa, B & Haji, J 2011, 'Pattern, trend and determinants of crop diversification: Empirical evidence from smallholders in Eastern Ethiopia', *Journal of Economics and Sustainable Development*, vol. 2, no. 8, pp. 78-89.

Midmore, DJ & Poudel, DD 1996, 'Asian vegetable production systems for the future', *Agricultural Systems*, vol. 50, no. 1, pp. 51-64.

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.

Miyata, S, Minot, N & Hu, D 2009, 'Impact of contract farming on income: Linking small farmers, packers, and supermarkets in China', *World Development*, vol. 37, no. 11, pp. 1781-1790.

MOA 2014a, 'Basis data ekspor-impor komoditi pertanian', <http://database.deptan.go.id/eksim/index1.asp#>.

MOA 2014b, *Horticultural development region plan 2015-2019*, Makassar.

Moore, GC & Benbasat, I 1991, 'Development of an instrument to measure the perceptions of adopting an information technology innovation', *Information Systems Research*, vol. 2, no. 3, pp. 192-222.

Morrison, M, Durante, J, Greig, J, Ward, J & Oczkowski, E 2012, 'Segmenting landholders for improving the targeting of natural resource management expenditures', *Journal of Environmental Planning and Management*, vol. 55, no. 1, pp.17-37.

Morrison, M, Oczkowski, E & Greig, J 2011, 'The primacy of human capital and social capital in influencing landholders' participation in programmes designed to improve environmental outcomes', *Australian Journal of Agricultural and Resource Economics*, vol. 55, no. 4, pp. 560-578.

Moser, CM & Barrett, CB 2006, 'The complex dynamics of smallholder technology adoption: The case of SRI in Madagascar', *Agricultural Economics*, vol. 35, no. 3, pp. 373-388.

Mueller, S & Lockshin, L 2013, 'Testing the robustness of best worst scaling for cross-national segmentation with different numbers of choice sets', *Food Quality and Preference*, vol. 27, no. 2, pp. 230-242.

Mueller, S & Rungie, C 2009, 'Is there more information in best-worst choice data? Using the attitude heterogeneity structure to identify consumer segments', *International Journal of Wine Business Research*, vol. 21, no. 1, pp. 24-40.

Narayanan, S 2014, 'Profits from participation in high value agriculture: Evidence of heterogeneous benefits in contract farming schemes in Southern India', *Food Policy*, vol. 44, pp. 142-157.

Narrod, C, Roy, D, Okello, J, Avendaño, B, Rich, K & Thorat, A 2009, 'Public-private partnerships and collective action in high value fruit and vegetable supply chains', *Food Policy*, vol. 34, no. 1, pp. 8-15.

Naylor, R 1992, 'Labour-saving technologies in the Javanese rice economy: Recent developments and a look into the 1990s', *Bulletin of Indonesian Economic Studies*, vol. 28, no. 3, pp. 71-91.

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.

Ng'ombe, J, Kalinda, T, Tembo, G & Kuntashula, E 2014, 'Econometric analysis of the factors that affect adoption of conservation farming practices by smallholder farmers in Zambia', *Journal of Sustainable Development*, vol. 7, no. 4, p. 124.

Nkonya, E, Schroeder, T & Norman, D 1997, 'Factors affecting adoption of improved maize seed and fertiliser in Northern Tanzania', *Journal of Agricultural Economics*, vol. 48, no. 13, pp. 1-12.

Noltze, M, Schwarze, S & Qaim, M 2012, 'Understanding the adoption of system technologies in smallholder agriculture: The system of rice intensification (SRI) in Timor Leste', *Agricultural Systems*, vol. 108, pp. 64-73.

OECD 2012, 'OECD Review of Agricultural Policies: Indonesia 2012', OECD Publishing, Paris.

Pannell, DJ, Marshall, GR, Barr, N, Curtis, A, Vanclay, F & Wilkinson, R 2006, 'Understanding and promoting adoption of conservation practices by rural landholders', *Animal Production Science*, vol. 46, no. 11, pp. 1407-1424.

Parsa, S, Morse, S, Bonifacio, A, Chancellor, TC, Condori, B, Crespo-Pérez, V, Hobbs, SL, Kroschel, J, Ba, MN & Rebaudo, F 2014, 'Obstacles to integrated pest management adoption in developing countries', *Proceedings of the National Academy of Sciences*, vol. 111, no. 10, pp. 3889-3894.

Peel, MJ 2014, 'Addressing unobserved endogeneity bias in accounting studies: Control and sensitivity methods by variable type', *Accounting and Business Research*, vol. 44, no. 5, pp. 545-571.

Pellegrini, L & Tasciotti, L 2014, 'Crop diversification, dietary diversity and agricultural income: Empirical evidence from eight developing countries', *Canadian Journal of Development Studies/Revue Canadienne d'études du développement*, vol. 35, no. 2, pp. 211-227.

Pingali, P 2007, 'Agricultural mechanization: Adoption patterns and economic impact', *Handbook of Agricultural Economics*, vol. 3, pp. 2779-2805.

Pingali, P 2015, 'Agricultural policy and nutrition outcomes-getting beyond the preoccupation with staple grains', *Food Security*, vol. 7, no. 3, pp. 583-591.

Pornpratansombat, P, Bauer, B & Boland, H 2011, 'The adoption of organic rice farming in Northeastern Thailand', *Journal of Organic Systems*, vol. 6, no. 3, pp. 4-12.

Poudel, DD, Midmore, DJ & Hargrove, WL 1998, 'An analysis of commercial vegetable farms in relation to sustainability in the uplands of Southeast Asia', *Agricultural Systems*, vol. 58, no. 1, pp. 107-128.

Prokopy, L, Floress, K, Klotthor-Weinkauf, D & Baumgart-Getz, A 2008, 'Determinants of agricultural best management practice adoption: Evidence from the literature', *Journal of Soil and Water Conservation*, vol. 63, no. 5, pp. 300-311.

Puspitawati, E 2013, 'Contracts and marketing decisions of Indonesian potato growers', PhD thesis, The University of Adelaide, Adelaide.

Qaim, M, Subramanian, A, Naik, G & Zilberman, D 2006, 'Adoption of bt cotton and impact variability: Insights from India', *Applied Economic Perspectives and Policy*, vol. 28, no. 1, pp. 48-58.

Rao, EJ & Qaim, M 2011, 'Supermarkets, farm household income, and poverty: Insights from Kenya', *World Development*, vol. 39, no. 5, pp. 784-796.

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, Stringer, R, Timmer, CP, Minot, N & Daryanto, A 2015, 'Transformation of the Indonesian agrifood system and the future beyond rice: A special issue', *Bulletin of Indonesian Economic Studies*, vol. 51, no. 3, pp. 369-373.

Reardon, T, Tschirley, D, Dolislager, M, Snyder, J, Hu, C & White, S 2014, 'Urbanization, diet change, and transformation of food supply chains in Asia', East Lansing, MI.

Rogers, EM 2003, *Diffusion of innovations*, 5th edition, Simon and Schuster, NY.

Rousseeuw, PJ & Kaufman, L 1990, *Finding groups in data: An introduction to cluster analysis*, Wiley Online Library.

Roy, D & Thorat, A 2008, 'Success in high value horticultural export markets for the small farmers: The case of Mahagrapes in India', *World Development*, vol. 36, no. 10, pp. 1874-1890.

Sadoulet, E & de Janvry, A 1995, *Quantitative development policy analysis*, The Johns Hopkins University Press, Baltimore and London.

Sahara, 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.

Sahara, Umberger, WJ & Stringer, R 2013, 'Marketing preferences of small chilli farmers in Indonesia: An application of best-worst scaling', *ISHS Acta Horticulturae*, vol. 1006.

Schipmann, C & Qaim, M 2009, 'Modern supply chains and product innovation: How can smallholder farmers benefit?', in *27th IAAE Conference, Beijing,* pp. 16-22.

Shiferaw, B, Kassie, M, Jaleta, M & Yirga, C 2014, 'Adoption of improved wheat varieties and impacts on household food security in Ethiopia', *Food Policy*, vol. 44, pp. 272-284.

Sichoongwe, K, Mapemba, L, Ng'ong'ola, D & Tembo, G 2014, 'The determinants and extent of crop diversification among smallholder farmers', MaSSP Working Paper 5.

Simon, PW, Bowman, MJ & Tanumihardjo, SA 2013, 'Horticultural crops as a source of carotenoids', in *Carotenoids and Human Health*, Springer, pp. 293-301.

Suryahadi, A & Hadiwidjaja, G 2011, 'The role of agriculture in poverty reduction in Indonesia', Jakarta: SMERU Research Institute.

Takahashi, K & Barrett, CB 2013, 'The system of rice intensification and its impacts on household income and child schooling: Evidence from rural Indonesia', *American Journal of Agricultural Economics*, vol. 96, no. 1, pp. 269-289.

Teklewold, H, Kassie, M & Shiferaw, B 2013, 'Adoption of multiple sustainable agricultural practices in rural Ethiopia', *Journal of Agricultural Economics*, vol. 64, no. 3, pp. 597-623.

Toiba, H, Umberger, WJ & Minot, N 2015, 'Diet transition and supermarket shopping behaviour: Is there a link?', *Bulletin of Indonesian Economic Studies*, vol. 51, no. 3, pp. 389-403.

Tornatzky, LG & Klein, KJ 1982, 'Innovation characteristics and innovation adoption implementation: A meta-analysis of findings', *IEEE Transactions on Engineering Management*, vol. 29, no. 1, pp. 28-45.

Umberger, WJ, Reardon, T, Stringer, R & Mueller, S 2015, 'Market-channel choices of Indonesian potato farmers: A best-worst scaling experiment', *Bulletin of Indonesian Economic Studies*, vol. 51, no. 3, pp. 461-477.

Useche, P, Barham, BL & Foltz, JD 2009, 'Integrating technology traits and producer heterogeneity: A mixed-multinomial model of genetically modified corn adoption', *American Journal of Agricultural Economics*, vol. 91, no. 2, pp. 444-461.

Vermeulen, B, Goos, P & Vandebroek, M 2010, 'Obtaining more information from conjoint experiments by best-worst choices', *Computational Statistics & Data Analysis*, vol. 54, no. 6, pp. 1426-1433.

Vermunt, JK & Magidson, J 2002, 'Latent class cluster analysis', in *Applied latent class analysis*, Cambridge University Press, Cambridge, pp. 89-106.

Vignola, R, Koellner, T, Scholz, RW & McDaniels, TL 2010, 'Decision-making by farmers regarding ecosystem services: Factors affecting soil conservation efforts in Costa Rica', *Land Use Policy*, vol. 27, no. 4, pp. 1132-1142.

Virchow, D, Hughes, JdA, Kasemsap, P, Dasgupta, S, Dutta, O, Ketsa, S, Chaikiattiyos, S, Linwattana, G, Kosiyachinda, S & Chantrasmi, V 2015, 'Small-scale vegetable production and marketing systems for food and nutrition security: Challenges and prospects for Southeast Asia', in *Proceedings of the Regional Symposium on Sustaining Small-Scale Vegetable Production and Marketing Systems for Food and Nutrition Security (SEAVEG2014), 25-27 February 2014, Bangkok, Thailand.,* AVRDC-The World Vegetable Center, pp. 432-441.

Wahida 2015, 'Food system transformation in Indonesia: Factors influencing demand and supply for alternative pest management farming systems', PhD thesis, The University of Adelaide, Adelaide.

Wale, E & Yalew, A 2007, 'Farmers' variety attribute preferences: Implications for breeding priority setting and agricultural extension policy in Ethiopia', *African Development Review*, vol. 19, no. 2, pp. 379-396.

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

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.

Wolf, CA & Tonsor, GT 2013, 'Dairy farmer policy preferences', *Journal of Agricultural and Resource Economics*, vol. 38, no. 2, pp. 220-234.

Wollni, M & Andersson, C 2013, 'Spatial patterns of organic agriculture adoption: Evidence from Honduras', GlobalFood Discussion Papers No. 20.

Wooldridge, JM 2010, *Econometric analysis of cross section and panel data: Second edition*, MIT Press, Cambridge, Mass., United States.

WorldBank 2007a, *Horticultural producers and supermarket development in Indonesia*, World Bank, Washington, DC, <http://documents.worldbank.org/curated/en/2007/06/8235822/horticultural-producers-supermarket-development-indonesia>.

WorldBank 2007b, *World development report 2008: Agriculture for development*, Washington, DC.

Yu, B & Nin-Pratt, A 2014, 'Fertilizer adoption in Ethiopia cereal production', *Journal of Development and Agricultural Economics*, vol. 6, no. 7, pp. 318-337.

Zakaria, WA, Prasmatiwi, FE, Abidin, Z, Murniati, K, Indriani, Y, Saleh, Y, Solimah, Marpaung, TH, Sutarsono, Buana, WP & Retno P, D 2015, *Efisiensi sistem produksi dan tataniaga hortikultura*, Analisis tematik st2013 subsektor, Badan Pusat Statistik, Jakarta.

Appendices

Appendix 1. Distance of districts to the nearest cities

No	Districts	Nearest cities of more than 500,000	Distance (km)
1	Bandung Barat	Cimahi	7.27
2	**Tasikmalaya**	**Tasikmalaya**	**7.66**
3	Bandung	Bandung	10.59
4	Bekasi	Bekasi	13.02
5	Sukoharjo	Surakarta	13.03
6	Bogor	Bogor	14.20
7	Karanganyar	Surakarta	16.06
8	Gresik	Surabaya	17.24
9	Ciamis	Tasikmalaya	17.36
10	Malang	Malang	17.82
11	Semarang	Semarang	17.96
12	Sidoarjo	Surabaya	18.21
13	Kendal	Semarang	24.20
14	Boyolali	Surakarta	25.24
15	**Demak**	**Semarang**	**25.80**
16	Sragen	Surakarta	27.02
17	Klaten	Surakarta	28.00
18	Bangkalan	Surabaya	29.48
19	Wonogiri	Surakarta	29.94
20	Garut	Tasikmalaya	33.43
21	Purwakarta	Cimahi	38.38
22	Karawang	Bekasi	38.66
23	Mojokerto	Surabaya	38.96
24	Sumedang	Bandung	39.03
25	Sukabumi	Bogor	39.66
26	Lamongan	Surabaya	40.16
27	**Subang**	**Bandung**	**41.67**
28	Pasuruan	Surabaya	43.77
29	Cianjur	Bogor	46.18
30	Temanggung	Semarang	46.85
31	Kuningan	Tasikmalaya	49.79
32	Jepara	Semarang	50.01
33	Kudus	Semarang	50.18
34	Blitar	Malang	51.71
35	Majalengka	Tasikmalaya	55.67
36	Grobogan	Semarang	56.00
37	Magetan	Surakarta	57.41
38	Sampang	Surabaya	58.32

Note: Districts with bold letters are selected districts using systematic random sampling.

Appendix 1. Distance of districts to the nearest cities (cont.)

No	Districts	Nearest cities of more than 500,000	Distance (km)
39	Magelang	Semarang	61.51
40	**Jombang**	**Surabaya**	**62.09**
41	Lumajang	Malang	67.83
42	Kediri	Malang	70.27
43	Ngawi	Surakarta	71.47
44	Wonosobo	Semarang	72.08
45	Pati	Semarang	72.79
46	Probolinggo	Surabaya	74.05
47	Batang	Semarang	76.14
48	Madiun	Surakarta	77.23
49	Pacitan	Surakarta	77.33
50	Ponorogo	Surakarta	78.82
51	Cirebon	Tasikmalaya	79.71
52	**Tulungagung**	**Malang**	**79.92**
53	Pekalongan	Semarang	83.04
54	Pamekasan	Surabaya	83.87
55	Tuban	Surabaya	87.53
56	Pemalang	Semarang	90.11
57	Purworejo	Surakarta	90.58
58	Nganjuk	Malang	90.91
59	Banjarnegara	Semarang	92.90
60	Indramayu	Bandung	94.83
61	Bojonegoro	Surabaya	96.61
62	Cilacap	Tasikmalaya	99.82
63	Trenggalek	Malang	102.01
64	Brebes	Tasikmalaya	106.35
65	**Rembang**	**Semarang**	**106.37**
66	Blora	Semarang	111.00
67	Kebumen	Semarang	115.01
68	Tegal	Tasikmalaya	115.45
69	Purbalingga	Semarang	115.77
70	Jember	Malang	119.71
71	Banyumas	Tasikmalaya	123.27
72	Sumenep	Surabaya	128.83
73	Bondowoso	Malang	132.01
74	Situbondo	Malang	156.21
75	Banyuwangi	Malang	194.21

Note: Districts with bold letters are selected districts using systematic random sampling.

Appendix 2. Lists of sub-district elevation for six selected districts

Districts	Sub-Districts	Elevation
1. Subang	1. Pagaden	Low
	2. Cipunagara	Low
	3. Compreng	Low
	4. Ciasem	Low
	5. Pusakanagara	Low
	6. Pusakajaya	Low
	7. Sukasari	Low
	8. Legonkulon	Low
	9. Blanakan	**Low**
	10. Patokbesi	Low
	11. Tambakdahan	Low
	12. Pagaden Barat	Low
	13. Subang	Low
	14. Cibogo	Low
	15. Kalijati	Low
	16. Cipeundey	Low
	17. Purwadadi	**Low**
	18. Cikaum	Low
	19. Pabuaran	Low
	20. Binong	Low
	21. Pamanukan	Low
	22. Cijambe	Low-Medium
	23. Dawuan	Low-Medium
	24. Ciater	**Medium-High**
	25. Jalancagak	Medium-High
	26. Sagalaherang	Medium-High
	27. Cisalak	Medium-High
	28. Kasomalang	**High**
	29. Serangpanjang	High
	30. Tanjungsiang	High

Notes: This study includes low elevation (<200m), medium elevation (200-600m) and high elevation (>600m). Sub-districts with bold letters are selected sub-districts using systematic random sampling.

Appendix 2. Lists of sub-district elevation for six selected districts (cont.)

Districts	Sub-Districts	Elevation
2. Tasikmalaya	1. Cikalong	Low
	2. Pancatengah	Low
	3. Cipatujah	Low
	4. Cikatomas	Low-Medium
	5. Cibalong	Low-Medium
	6. Karangnunggal	Low-Medium
	7. Bantarkalong	Low-Medium
	8. Cineam	**Low-Medium**
	9. Jamanis	Medium
	10. Rajapolah	Medium
	11. Sukaraja	Medium
	12. Salopa	Medium
	13. Jatiwaras	Medium
	14. Culamega	Medium
	15. Bojongasih	Medium
	16. Singaparna	Medium
	17. Sukarame	Medium
	18. Manonjaya	**Medium**
	19. Padakembang	Medium
	20. Karangjaya	Medium
	21. Gunungtanjung	Medium
	22. Sukaresik	Medium
	23. Parungponteng	Medium
	24. Tanjungjaya	Medium
	25. Mangunreja	Medium
	26. Leuwisari	Medium High
	27. Sukaratu	Medium-High
	28. Sodonghilir	**Medium-High**
	29. Cisayong	Medium-High
	30. Ciawi	Medium-High
	31. Kadipaten	Medium-High
	32. Pagerageung	Medium-High
	33. Taraju	Medium-High
	34. Bojonggambir	Medium-High
	35. Salawu	Medium-High
	36. Puspahiang	Medium-HIgh
	37. Cigalontang	Medium-High
	38. Sariwangi	Medium-High
	39. Sukahening	**High**

Notes: This study includes low elevation (<200m), medium elevation (200-600m) and high elevation (>600m). Sub-districts with bold letters are selected sub-districts using systematic random sampling.

Appendix 2. Lists of sub-district elevation for six selected districts (cont.)

Districts	Sub-Districts	Elevation
3. Demak	1. Demak	Low
	2. Wonosalam	**Low**
	3. Karangtengah	Low
	4. Bonang	Low
	5. Wedung	Low
	6. Mijen	**Low**
	7. Karanganyar	Low
	8. Gajah	Low
	9. Guntur	Low
	10. Dempet	**Low**
	11. Sayung	Low
	12. Mranggen	Low
	13. Karangawen	**Low**
	14. Kebonagung	Low
4. Rembang	1. Rembang	Low
	2. Kaliori	**Low**
	3. Sulang	Low
	4. Sumber	Low
	5. Bulu	Low
	6. Pamotan	**Low**
	7. Sarang	Low
	8. Sale	Low
	9. Lasem	Low-Medium
	10. Kragan	**Low-Medium**
	11. Pancur	Low-Medium
	12. Sluke	Low-Medium
	13. Sedan	**Low-Medium**
	14. Gunem	Low-Medium

Notes: This study includes low elevation (<200m), medium elevation (200-600m) and high elevation (>600m). Sub-districts with bold letters are selected sub-districts using systematic random sampling.

Appendix 2. Lists of sub-district elevation for six selected districts (cont.)

Districts	Sub-Districts	Elevation
5. Jombang	1. Bandar Kedungmulyo	Low
	2. Bareng	Low
	3. Diwek	**Low**
	4. Gudo	Low
	5. Jogoroto	Low
	6. Jombang	Low
	7. Kabuh	Low
	8. Kesamben	**Low**
	9. Kudu	Low
	10. Megaluh	Low
	11. Mojoagung	Low
	12. Mojowarno	Low
	13. Ngusikan	Low
	14. Ngoro	**Low**
	15. Perak	Low
	16. Peterongan	Low
	17. Plandaan	Low
	18. Ploso	Low
	19. Sumobito	**Low**
	20. Tembelang	Low
	21. Wonosalam	Medium-High
6. Tulungagung	1 Besuki	Low
	2 Bandung	Low
	3 Pakel	Low
	4 Campurdarat	**Low**
	5 Tanggunggunung	Low
	6 Kalidawir	Low
	7 Pucanglaban	Low
	8 Ngunut	Low
	9 Rejotangan	**Low**
	10 Sumbergempol	Low
	11 Boyolangu	Low
	12 Tulungagung	Low
	13 Ngantru	Low
	14 Kedungwaru	**Low**
	15 Karangrejo	Low
	16 Kauman	Low
	17 Gondang	Low
	18 Pagerwojo	**Medium-High**
	19 Sendang	Medium-High

Notes: This study includes low elevation (<200m), medium elevation (200-600m) and high elevation (>600m). Sub-districts with bold letters are selected sub-districts using systematic random sampling.

Appendix 3. Lists of 24 selected sub-districts for six selected districts

Districts	Sub-Districts	Elevation
1. Subang	1. Blanakan	Low
	2. Purwadadi	Low
	3. Ciater	Medium-High
	4. Kasomalang	High
2. Tasikmalaya	1. Cineam	Low-Medium
	2. Manonjaya	Medium
	3. Sodonghilir	Medium-High
	4. Sukahening	High
3. Demak	1. Wonosalam	Low
	2. Mijen	Low
	3. Dempet	Low
	4. Karangawen	Low
4. Rembang	1. Kaliori	Low
	2. Pamotan	Low
	3. Kragan	Low-Medium
	4. Sedan	Low-Medium
5. Jombang	1. Diwek	Low
	2. Kesamben	Low
	3. Ngoro	Low
	4. Sumobito	Low
6. Tulungagung	1. Campurdarat	Low
	2. Rejotangan	Low
	3. Kedungwaru	Low
	4. Pagerwojo	Medium-High

Note: This study includes low elevation (<200m), medium elevation (200-600m) and high elevation (>600m).

Appendix 4. Lists of villages for selected sub-districts

Districts	Subang	Subang	Subang	Subang
Sub-Districts	Blanakan	Purwadadi	Ciater	Kasomalang
Villages	1. Cilamaya hilir	1. Koranji	**1. Nagrak**	**1. Pasanggrahan**
	2. Cilamaya girang	**2. Wanakerta**	2. Ciater	2. Sindangsari
	3. Rawamekar	3. Belendung	**3. Cibitung**	**3. Bojongloa**
	4. Rawameneng	4. Pagon	4. Cibeusi	4. Tenjolaya
	5. Jayamukti	**5. Parapatan**	**5. Palasari**	**5. Sukamelang**
	6. Blanakan	6. Pasirbungur	6. Sanca	6. Kasomalang wetan
	7. Langensari	7. Purwadadi timur	**7. Cisaat**	**7. Kasomalang kulon**
	8. Muara	**8. Purwadadi barat**		8. Cimanglid
	9. Tanjungtiga	9. Rancamahi		
		10. Panyingkiran		

Districts	Tasikmalaya	Tasikmalaya	Tasikmalaya	Tasikmalaya
Sub-Districts	Cineam	Manonjaya	Sodonghilir	Sukahening
Villages	**1. Ancol**	1. Batusumur	1. Cipaingeun	**1. Banyurasa**
	2. Ciampanan	**2. Cihaur**	2. Dempet	2. Banyuresmi
	3. Cijulang	3. Cibeber	**3. Cikalong**	**3. Calincing**
	4. Cikondang	**4. Margahayu**	4. Harjowinangun	4. Kudadepa
	5. Cineam	5. Gunajaya	5. Leuwidulang	**5. Kiarajanngkung**
	6. Cisarua	6. Cilangkap	6. Muncang	6. Sukahening
	7. Madiasari	**7. Margaluyu**	7. Cukangjayaguna	**7. Sundakerta**
	8. Pasirmukti	8. Manonjaya	**8. Cukangkawung**	
	9. Nagaratengah	9. Kalimanggis	9. Raksajaya	
	10. Rajadatu	10. Kamulyan	10. Sukabakti	
		11. Pasirbatang	11. Parumasan	
		12. Pasirpanjang	**12. Pakalongan**	
			13. Kramat	
			14. Kuwu	
			15. Sodonghilir	
			16. Sepatnunggal	

Note: Villages with bold letters are selected villages using systematic random sampling.

Appendix 4. Lists of villages for selected sub-districts (cont.)

Districts	**Demak**	**Demak**	**Demak**	**Demak**
Sub-Districts	Wonosalam	Mijen	Dempet	Karangawen
Villages	1. **Bunderan**	1. Banteng mati	1. Merak	1. Jragung
	2. Tlogodowo	**2. Mlaten**	2. Karangrejo	**2. Wonosekar**
	3. Kalianyar	3. Ngelo wetan	**3. Botosengon**	3. Margohayu
	4. Doreng	4. Geneng	4. Baleromo	4. Bumirejo
	5. Getas	5. Bakung	5. Jerukgulung	5. Tlogorejo
	6. Kerangkulon	**6. Bermi**	6. Kunir	**6. Teluk**
	7. Pilangrejo	7. Tanggul	7. Brakas	7. Karangawen
	8. Lempuyang	8. Ngelo kulon	**8. Gempoldenok**	8. Kuripan
	9. Tlogorejo	9. Rejosari	9. Sidomulyo	**9. Rejosari**
	10. Karangrowo	**10. Pasir**	10. Balerejo	10. Pundenarum
	11. Sido mulyo	11. Ngegot	11. Kebonsari	11. Sido rejo
	12. Mojodemak	12. Jleper	**12. Kedungori**	**12. Brambang**
	13. Kendaldoyong	13. Mijen	13. Dempet	
	14. Wonosalam	**14. Pecuk**	14. Harjowinangun	
	15. Karangrejo	15. Gempolsongo	15. Kramat	
	16. Jogoloyo		**16. Kuwu**	
	17. Botorejo			
	18. Mranak			
	19. Mrisen			
	20. Kuncir			
	21. Trengguli			

Note: Villages with bold letters are selected villages using systematic random sampling.

Appendix 4. Lists of villages for selected sub-districts (cont.)

Districts	Rembang	Rembang	Rembang	Rembang
Sub-Districts	Kaliori	Pamotan	Sedan	Kragan
Villages	**1. Meteseh**	1. Megal	1. Ngulahan	1. Tanjungsari
	2. Maguan	2. Ngemplakrejo	**2. Pacing**	2. Sendangmulyo
	3. Sidomulyo	**3. Ringin**	3. Karas	3. Sendangwaru
	4. Wiroto	4. Samaran	4. Mojosari	**4. Ngasinan**
	5. Gunungsari	5. Pragen	5. Gesikan	5. Kendalagung
	6. Kuangsan	6. Bamban	6. Sambiroto	6. Karangharjo
	7. Banggi	7. Bangunrejo	7. Sedan	7. Tanjungan
	8. Mojorembun	8. Pamotan	**8. Sidomulyo**	8. Kebloran
	9. Karangsekar	**9. Gambiran**	9. Sidorejo	9. Karanganyar
	10. Tasikharjo	10. Tempaling	10. Karangasem	10. Karanglincak
	11. Pengkol	11. Joho	11. Kedungringin	**11. Mojokerto**
	12. Sambiyan	12. Mlagen	12. Candimulyo	12. Kragan
	13. Sendangagung	13. Kepohagung	**13. Gandirejo**	13. Sendang
	14. Tunggulsari	14. Mlawat	14. Lemahputih	14. Balongmulyo
	15. Tambakagung	**15. Sidorejo**	15. Kumbo	15. Narukan
	16. Mojowarno	16. Ketangi	16. Dadapan	16. Sudan
	17. Dresi kulon	17. Sendangagung	17. Sambong	17. Terjan
	18. Dresi wetan	18. Gegersimo	**18. Jambeyan**	**18. Tegalmulyo**
	19. Babadan	19. Sumbangrejo	19. Kenongo	19. Watupecah
	20. Purworejo	20. Tulung	20. Bogorejo	20. Plawangan
	21. Bogoharjo	**21. Japerejo**	21. Menoro	21. Sumurpule
	22. Banyudono	22. Segoromulyo		22. Sumurtawang
	23. Pantiharjo	23. Sumberejo		23. Pandangan kulon
				24. Pandangan wetan
				25. Woro
				26. Sumbergayam
				27. Sumbersari

Note: Villages with bold letters are selected villages using systematic random sampling.

Appendix 4. Lists of villages for selected sub-districts (cont.)

Districts	**Jombang**	**Jombang**	**Jombang**	**Jombang**
Sub-Districts	Diwek	Kesamben	Ngoro	Sumobito
Villages	1. Kayangan	**1. Jombok**	1. Jombok	1. Plosokerep
	2. Puton	2. Kedung betik	**2. Genukwatu**	2. Jogoloyo
	3. Bulurejo	3. Watu dakon	3. Rejoagung	3. Mlaras
	4. Bendet	**4. Pojok rejo**	4. Kauman	4. Plemahan
	5. Grogol	5. Carang rejo	**5. Kesamben**	**5. Talun kidul**
	6. Jatirejo	6. Blimbing	6. Ngoro	6. Badas
	7. Kwaron	7. Wuluh	7. Pulorejo	7. Nglele
	8. Cukir	**8. Kedung mlati**	**8. Gajah**	8. Trawasan
	9. Keras	9. Kesamben	9. Sidowarek	9. Sebani
	10. Watugaluh	10. Podoroto	10. Banyuarang	**10. Palrejo**
	11. Jatipelem	**11. Jati duwur**	11. Kertorejo	11. Segodorejo
	12. Pundong	12. Jombatan	**12. Badang**	12. Kedungpapar
	13. Brambang	13. Pojok kulon	13. Sugihwaras	13. Sumobito
	14. Diwek	14. Gumulan		14. Curah malang
	15. Ceweng			15. Budugsidorejo
	16. Ngudirejo			**16. Kendalsari**
	17. Kedawong			17. Brudu
	18. Bandung			18. Madyo puro
	19. Balong besuk			19. Bakalan
	20. Pandanwangi			20. Gedangan
				21. Mentoro

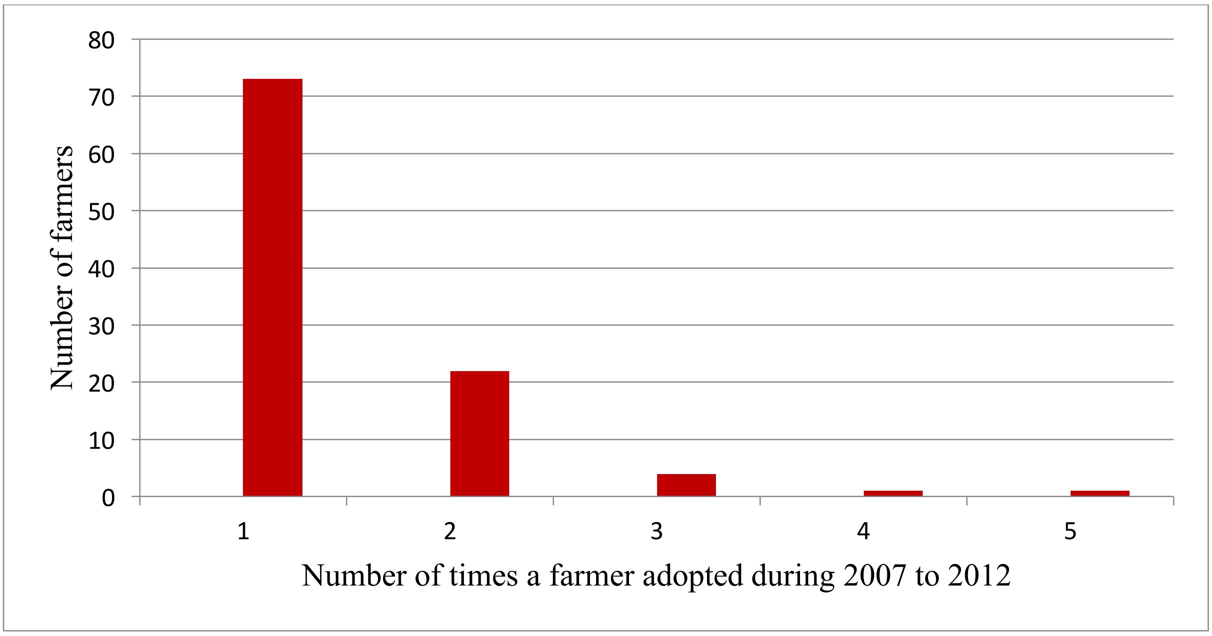
Note: Villages with bold letters are selected villages using systematic random sampling.

Appendix 4. Lists of villages for selected sub-districts (cont.)

Districts	**Tulungagung**	**Tulungagung**	**Tulungagung**	**Tulungagung**
Sub-Districts	Campurdarat	Rejotangan	Kedungwaru	Pagerwojo
Villages	1. Ngentrong	**1. Tenggong**	1. Plosokandang	1. Wonorejo
	2. Sawo	2. Panjerejo	2. Tunggulsari	2. Kedung cangkring
	3. Gedangan	3. Karangasari	**3. Ringinpitu**	**3. Mulyosari**
	4. Gamping	**4.** Tugu	4. Loderesan	4. Segawe
	5. Campurdarat	**5. Sukorejo Wetan**	5. Bulusari	5. Penjor
	6. Wates	**6.** Tanen	6. Bangoan	**6. Samar**
	7. Pelem	7. Sumberagung	7. Rejoagung	7. Sidomulyo
	8. Pojok	**8.** Blimbing	**8. Kedungwaru**	8. Kradinan
	9. Tanggung	**9. Pakisrejo**	9. Plandaan	**9. Pagerwojo**
		10. Tegalrejo	10. Mangunsari	10. Gondang gunung
		11. Banjarejo	11. Tawangsari	**11. Gambiran**
		12. Jatidowo	12. Winong	
		13. Tenggur	**13. Majan**	
		14. Buntaran	14. Simo	
		15. Aryojeding	15. Ketanon	
		16. Rejotangan	16. Gendingan	
			17. Tapan	
			18. Ngujang	
			19. Boro	

Note: Villages with bold letters are selected villages using systematic random sampling.

Appendix 5. Intensity of adoption of new horticultural crops (2007-2012) (n = 101)



Appendix 6. Crop produced by Indonesian farmers in 2011/2012 per plot (n = 960)

	All Year		Rainy Season		Dry Season 1		Dry Season 2	
Crops	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Staple food crops								
Rice	1,882	41.83	929	45.58	724	50.63	229	22.21
Maize	435	9.67	80	3.93	163	11.4	192	18.62
Mung bean	125	2.78	7	0.34	34	2.38	84	8.15
Soybean	95	2.11	5	0.25	16	1.12	74	7.18
Cassava	66	1.47	43	2.11	11	0.77	12	1.16
Groundnuts	56	1.24	13	0.64	22	1.54	21	2.04
Red bean	14	0.31	2	0.1	7	0.49	5	0.48
Sweet Potato	13	0.29	4	0.2	8	0.56	1	0.1
Others beans/pulses	6	0.13	1	0.05	2	0.14	3	0.29
Other tubers	3	0.07	3	0.15	-		-	
Vegetable crops								
Chillies	132	2.93	53	2.6	48	3.36	31	3.01
Shallots	102	2.27	48	2.36	31	2.17	23	2.23
Cucumber	81	1.8	24	1.18	37	2.59	20	1.94
String bean	42	0.93	12	0.59	17	1.19	13	1.26
Tomato	37	0.82	10	0.49	15	1.05	12	1.16
Eggplant	26	0.58	12	0.59	7	0.49	7	0.68
Chinese cabbage	23	0.51	9	0.44	11	0.77	3	0.29
Green bean	22	0.49	4	0.2	8	0.56	10	0.97
Kangkung	21	0.47	11	0.54	5	0.35	5	0.48
Other vegetable	20	0.44	8	0.39	4	0.28	8	0.78
Spinach	17	0.38	7	0.34	6	0.42	4	0.39
Cabbage	10	0.22	3	0.15	4	0.28	3	0.29
Gherkin	3	0.07	1	0.05	1	0.07	1	0.1
Leek	3	0.07	1	0.05	2	0.14	-	
Broccoli	1	0.02	-		-		1	0.1
Caisin/bok choi	1	0.02	-		-		1	0.1
Ginger	1	0.02	1	0.05	-		-	

Appendix 6. Crop produced by Indonesian farmers in 2011/2012 per plot (n = 960) (cont.)

	All Year		**Rainy Season**		**Dry Season 1**		**Dry Season 2**	
Crops	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Fruit crops								
Banana	115	2.56	69	3.39	23	1.61	23	2.23
Snake fruit	69	1.53	49	2.4	10	0.7	10	0.97
Rambutan	65	1.44	59	2.89	6	0.42	-	
Other fruit	64	1.42	51	2.5	10	0.7	3	0.29
Mangosteen	34	0.76	28	1.37	4	0.28	2	0.19
Duku	33	0.73	25	1.23	7	0.49	1	0.1
Pineapple	27	0.6	10	0.49	7	0.49	10	0.97
Watermelon	25	0.56	1	0.05	18	1.26	6	0.58
Mango	17	0.38	10	0.49	1	0.07	6	0.58
Avocado	15	0.33	11	0.54	1	0.07	3	0.29
Melon	11	0.24	4	0.2	4	0.28	3	0.29
Papaya	11	0.24	6	0.29	3	0.21	2	0.19
Jambu air	6	0.13	3	0.15	-		3	0.29
Star fruit	5	0.11	3	0.15	1	0.07	1	0.1
Other crops								
Other perrenial crops	346	7.69	276	13.54	29	2.03	41	3.98
Sugarcane	88	1.96	17	0.83	23	1.61	48	4.66
Grass or forage crops	85	1.89	29	1.42	28	1.96	28	2.72
Coconut	82	1.82	40	1.96	23	1.61	19	1.84
Other spices	63	1.4	40	1.96	14	0.98	9	0.87
Tobbaco	60	1.33	-		20	1.4	40	3.88
Tea	35	0.78	14	0.69	12	0.84	9	0.87
Other annual crops	6	0.13	2	0.1	3	0.21	1	0.1
Total	4,499	100	2,038	100	1,430	100	1,031	100

Appendix 7. Farm land allocated by Indonesian farmers in 2011/2012 per crop (n = 960)

Crops	Obs	Mean	Std. Dev.	Min	Max
Staple food crops					
Rice	890	1.03	1.21	0.01	11.00
Maize	309	0.65	0.66	0.01	4.50
Mung bean	121	0.67	0.65	0.03	4.20
Soybean	90	0.53	0.54	0.01	2.54
Cassava	62	0.35	0.39	0.01	2.14
Groundnuts	43	0.43	0.44	0.01	1.96
Red bean	14	0.30	0.15	0.10	0.64
Sweet Potato	12	0.51	0.58	0.03	2.10
Others beans/pulses	5	0.27	0.26	0.05	0.71
Other tubers	3	0.30	0.13	0.14	0.39
Vegetable crops					
Chillies	118	0.38	0.33	0.01	1.90
Cucumber	60	0.44	0.48	0.01	2.10
Shallots	46	1.07	0.85	0.10	3.44
Tomatoes	34	0.33	0.30	0.04	1.50
String bean	32	0.38	0.39	0.07	1.50
Eggplant	21	0.43	0.33	0.04	1.40
Kangkung	17	0.38	0.35	0.07	1.08
Chinese cabbage	15	0.47	0.31	0.08	1.00
Green bean	15	0.34	0.61	0.04	2.50
Other vegetables	14	0.43	0.25	0.04	1.00
Spinach	12	0.57	0.29	0.14	1.08
Cabbage	6	0.35	0.29	0.10	0.75
Leek	3	0.19	0.06	0.13	0.25
Broccoli	1	0.21	.	0.21	0.21
Caisin/bok choi	1	0.03	.	0.03	0.03
Gherkin	1	0.13	.	0.13	0.13
Ginger	1	0.03	.	0.03	0.03

Appendix 7. Farm land allocated by Indonesian farmers in 2011/2012 per crop (n = 960) (cont.)

Crops	Obs	Mean	Std. Dev.	Min	Max
Fruit crops					
Banana	80	0.40	0.59	0.00	3.64
Rambutan	62	0.42	0.43	0.02	2.00
Snake fruit	50	0.49	0.70	0.04	4.50
Other fruits	49	0.49	0.62	0.03	3.04
Mangosteen	33	0.31	0.30	0.00	1.14
Duku	32	0.24	0.19	0.04	0.82
Watermelon	22	0.66	0.44	0.08	1.70
Mango	16	0.42	0.44	0.00	1.50
Avocado	15	0.28	0.29	0.00	1.00
Pineapple	14	0.92	0.92	0.14	3.57
Melon	7	0.60	0.37	0.06	1.00
Papaya	7	0.29	0.15	0.14	0.57
Jambu air	6	0.27	0.25	0.03	0.71
Star fruit	3	0.09	0.05	0.03	0.12
Other crops					
Other perrenial crops	216	0.52	0.72	0.00	6.00
Sugarcane	73	0.91	0.91	0.06	6.00
Tobbaco	58	0.44	0.37	0.07	2.30
Other spices	47	0.39	0.42	0.00	2.00
Coconut	43	0.52	0.70	0.00	3.75
Grass or forage crops	28	0.67	0.61	0.04	2.14
Tea	14	1.14	0.99	0.06	3.00
Other annual crops	4	0.30	0.19	0.12	0.50

Appendix 8. 3SLS results of the value of food supply for all sample

VARIABLES	Total value of horticultural crops per ha (million IDR/ha) (1)	Total value of staple crops per ha (million IDR/ha) (2)	Total value of estate crops per ha (million IDR/ha) (3)	Wage income per ha (million IDR/ha) (4)	Net Effect on agricultural value per ha (million IDR/ha) (5)	Total net effect (million IDR/ha) (6)
Diversification (% horticultural land)	1.2843***	-0.3142***	-0.1054	-0.2165	0.8647***	0.6482**
	(0.2644)	(0.0616)	(0.0644)	(0.1322)		
Age HH (years)	-0.0835	-0.1131	-0.0859	-0.4564**		
	(0.0737)	(0.0867)	(0.0906)	(0.1845)		
Education HH (years)	-0.2124	-0.2454	-0.0503	0.7853		
	(0.2237)	(0.3026)	(0.3152)	(0.6432)		
Number of adult aged between 16-65	0.5423	-0.5308	-1.0940	5.1723**		
	(0.7796)	(0.9629)	(1.0132)	(2.0804)		
Mobile phone ownership (unit)	0.2954	0.5798	1.6078*	2.7542		
	(0.6774)	(0.8793)	(0.9212)	(1.8913)		
Transportation asset (million Rp)	0.0016	0.0570	0.0348	0.1576*		
	(0.0329)	(0.0437)	(0.0458)	(0.0940)		
Production asset (million Rp)	0.1942	0.8163***	0.9576***	-0.4410		
	(0.1714)	(0.2298)	(0.2416)	(0.4940)		
Storage asset (million Rp)	-0.0304	0.0195	-0.0201	0.0308		
	(0.0395)	(0.0472)	(0.0493)	(0.1013)		
Farm size (ha)	-0.6869	-5.9237***	-1.2098	-14.230***		
	(1.0535)	(1.1989)	(1.2535)	(2.5709)		
% of rented land	0.0128	-0.0658**	0.0389	-0.1091		
	(0.0414)	(0.0309)	(0.0324)	(0.0665)		
% of irrigated land	0.0797***	0.2568***	-0.0784***	-0.0460		
	(0.0197)	(0.0215)	(0.0227)	(0.0460)		
Remittance income (million Rp)	0.0103	-0.0426	-0.0050	-0.0364		
	(0.0471)	(0.0625)	(0.0657)	(0.1349)		
Pension income (million Rp)	0.0847	0.0515	-0.1379	0.8086		
	(0.1821)	(0.2424)	(0.2545)	(0.5223)		

Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix 8. 3SLS results of the value of food supply for all sample (cont.)

VARIABLES	Total value of horticultural crops per ha (million IDR/ha) (1)	Total value of staple crops per ha (million IDR/ha) (2)	Total value of estate crops per ha (million IDR/ha) (3)	Wage income per ha (million IDR/ha) (4)	Net Effect on agricultural value per ha (million IDR/ha) (5)	Total net effect (million IDR/ha) (6)
Distance to nearest urban market (km)	0.0551	-0.0781	-0.2118***	-0.2676*		
	(0.0554)	(0.0663)	(0.0691)	(0.1416)		
Elevation (m)	-0.0046	-0.0096***	0.0002	0.0025		
	(0.0035)	(0.0033)	(0.0034)	(0.0069)		
Member in farmer group (1/0)	2.6239	4.6814**	1.1948	-0.7941		
	(1.7833)	(2.2752)	(2.2196)	(4.5233)		
Horticultural farming experience (1/0)	-21.8846***					
	(6.8619)					
FFS GAP/GHP (1/0)	-0.0029					
	(2.6051)					
Received to extension support in horticulture production (1/0)	-5.0028					
	(3.2129)					
FFS ICM (1/0)		-2.1104				
		(2.0195)				
Received to extension support in staple production (1/0)		5.5557***				
		(1.8668)				
Grain mill ownership (1/0)		0.4277				
		(2.2163)				
Received to extension support in estate crop production (1/0)			8.5741***			
			(2.7679)			
Constant	-4.7049	32.138***	17.9069**	41.919***		
	(6.5354)	(6.8431)	(7.1248)	(14.5561)		
Observations	959	959	959	959		
Chi2	295.19***	375.38***	57.69	84.9***		
R-squared	0.278	0.307	0.063	0.086		

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 9. 3SLS results of the value of food supply in lowland areas

VARIABLES	Total value of horticultural crops per ha (million IDR/ha) (1)	Total value of staple crops per ha (million IDR/ha) (2)	Total value of estate crops per ha (million IDR/ha) (3)	Wage income per ha (million IDR/ha) (4)	Net Effect on agricultural output per ha (million IDR/ha) (5)	Total net effect (million IDR/ha) (6)
Diversification (% horticultural land)	0.9779**	-0.3652***	-0.2184***	-0.3114**	0.3943	0.0829
	(0.4779)	(0.0647)	(0.0570)	(0.1516)		
Age HH (years)	-0.0304	-0.0252	-0.0037	-0.5805***		
	(0.0839)	(0.0885)	(0.0781)	(0.2077)		
Education HH (years)	-0.2874	0.1121	0.0505	0.0426		
	(0.2222)	(0.2878)	(0.2509)	(0.6670)		
Number of adult aged between 16-65	-0.4705	-0.1092	-0.4605	5.8847***		
	(0.8472)	(0.9151)	(0.8121)	(2.1616)		
Mobile phone ownership (unit)	0.9146	0.0574	1.3158*	0.7846		
	(0.6780)	(0.8808)	(0.7771)	(2.0652)		
Transportation asset (million Rp)	0.0089	0.0530	0.0362	0.1972**		
	(0.0297)	(0.0391)	(0.0346)	(0.0921)		
Production asset (million Rp)	0.1625	0.7882***	-0.0753	-0.1583		
	(0.1556)	(0.2024)	(0.1798)	(0.4764)		
Storage asset (million Rp)	-0.0088	0.0158	-0.0060	0.0924		
	(0.0452)	(0.0403)	(0.0355)	(0.0945)		
Farm size (ha)	-1.3910	-4.7958***	0.9245	-13.577***		
	(1.5726)	(1.1036)	(0.9746)	(2.5865)		
% of rented land	0.0612	-0.0529*	0.0643***	-0.0987		
	(0.0466)	(0.0274)	(0.0243)	(0.0647)		
% of irrigated land	0.0448	0.2346***	-0.1034***	-0.0609		
	(0.0278)	(0.0208)	(0.0184)	(0.0484)		
Remittance income (million Rp)	0.0076	-0.0528	-0.0028	-0.0417		
	(0.0409)	(0.0535)	(0.0474)	(0.1261)		
Pension income (million Rp)	0.0504	0.0170	-0.0963	0.2185		
	(0.1811)	(0.2313)	(0.2049)	(0.5449)		

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 9. 3SLS results of the value of food supply in lowland areas (cont.)

VARIABLES	Total value of horticultural crops per ha (million IDR/ha) (1)	Total value of staple crops per ha (million IDR/ha) (2)	Total value of estate crops per ha (million IDR/ha) (3)	Wage income per ha (million IDR/ha) (4)	Net Effect on agricultural value per ha (million IDR/ha) (5)	Total net effect (million IDR/ha) (6)
Distance to nearest urban market (km)	-0.0144	-0.0420	-0.2408***	-0.3224*		
	(0.0597)	(0.0716)	(0.0629)	(0.1674)		
Member in farmer group (1/0)	1.2301	2.6626	1.6313	0.2380		
	(1.5739)	(2.1699)	(1.8235)	(4.8385)		
Horticultural farming experience (1/0)	-12.0313					
	(11.6569)					
FFS GAP/GHP (1/0)	0.3776					
	(3.4534)					
Received to extension support in horticulture production (1/0)	-0.2374					
	(6.6462)					
FFS ICM (1/0)		3.0523				
		(1.9815)				
Received to extension support in staple production (1/0)		2.6403				
		(1.7647)				
Grain mill ownership (1/0)		0.3632				
		(1.8124)				
Received to extension support in estate crop production (1/0)			10.999***			
			(2.8515)			
Constant	-1.2451	26.1706***	13.8953**	55.6947***		
	(8.1396)	(6.8999)	(6.0618)	(16.1345)		
Observations	690	690	690	690		
Chi2	277.76***	323.86***	82.42***	73.02***		
R-squared	0.448	0.344	0.102	0.099		

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 10. 3SLS results of the value of food supply in highland areas

VARIABLES	Total value of horticultural crops per ha (million IDR/ha) (1)	Total value of staple crops per ha (million IDR/ha) (2)	Total value of estate crops per ha (million IDR/ha) (3)	Wage income per ha (million IDR/ha) (4)	Net Effect on agricultural output per ha (million IDR/ha) (5)	Total net effect (million IDR/ha) (6)
Diversification (% horticultural land)	0.8652***	-0.1812	0.0307	0.0696	0.7147**	0.7843*
	(0.2676)	(0.1482)	(0.1427)	(0.2795)		
Age HH (years)	-0.3388***	-0.3337	-0.0973	-0.0260		
	(0.1088)	(0.2157)	(0.2035)	(0.3943)		
Education HH (years)	0.3557	-0.7619	1.0877	4.5616**		
	(0.4818)	(0.9541)	(0.9161)	(1.7870)		
Number of adult aged between 16-65	1.9620	-0.9912	-0.3257	6.5473		
	(1.4673)	(2.8279)	(2.7213)	(5.3788)		
Mobile phone ownership (unit)	-1.0703	-0.1512	-0.5041	8.5564*		
	(1.2542)	(2.2991)	(2.2140)	(4.3781)		
Transportation asset (million Rp)	0.0134	0.1248	-0.1201	-0.1141		
	(0.0890)	(0.1737)	(0.1667)	(0.3298)		
Production asset (million Rp)	0.1440	0.3595	14.0489***	-2.2444		
	(0.5865)	(1.1134)	(1.0647)	(2.1046)		
Storage asset (million Rp)	0.5853	0.0283	0.2834	-0.8890		
	(0.5276)	(1.0260)	(0.9812)	(1.9420)		
Farm size (ha)	-2.0487	-11.577***	-8.4814**	-18.3773**		
	(2.1629)	(4.2062)	(4.0310)	(7.9772)		
% of rented land	0.0499	-0.1532	-0.0999	-0.1933		
	(0.1403)	(0.1390)	(0.1354)	(0.2635)		
% of irrigated land	0.1344***	0.3223***	-0.0706	0.0332		
	(0.0320)	(0.0614)	(0.0591)	(0.1155)		
Remittance income (million Rp)	-0.0806	0.2970	0.0717	-0.5063		
	(0.2614)	(0.5113)	(0.4906)	(0.9710)		
Pension income (million Rp)	-0.0117	0.0132	-0.1667	2.6866**		
	(0.3499)	(0.6905)	(0.6576)	(1.3013)		

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 10. 3SLS results of the value of food supply in highland areas (cont.)

VARIABLES	Total value of horticultural crops per ha (million IDR/ha) (1)	Total value of staple crops per ha (million IDR/ha) (2)	Total value of estate crops per ha (million IDR/ha) (3)	Wage income per ha (million IDR/ha) (4)	Net Effect on agricultural value per ha (million IDR/ha) (5)	Total net effect (million IDR/ha) (6)
Distance to nearest urban market (km)	0.0900	-0.1531	-0.0610	-0.2725		
	(0.0768)	(0.1428)	(0.1335)	(0.2614)		
Member in farmer group (1/0)	2.6131	11.5755*	-1.3549	-5.9859		
	(3.7936)	(6.4461)	(5.6477)	(11.0491)		
Horticultural farming experience (1/0)	-14.9485**					
	(7.5637)					
FFS GAP/GHP (1/0)	4.1325					
	(3.7499)					
Received to extension support in horticulture production (1/0)	-0.6890					
	(2.9736)					
FFS ICM (1/0)		-9.9028*				
		(5.0722)				
Received to extension support in staple production (1/0)		15.4091***				
		(5.0812)				
Grain mill ownership (1/0)		13.5828				
		(24.9403)				
Received to extension support in estate crop production (1/0)			5.2720			
			(4.8194)			
Constant	0.8464	33.9999*	9.0838	-18.6023		
	(10.2957)	(18.2703)	(17.3654)	(33.8355)		
Observations	269	269	269	269		
Chi2	153.81***	82.09***	185.81***	38.37***		
R-squared	0.497	0.251	0.406	0.122		

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 11. 3SLS results of the farm household income for all sample

VARIABLES	Total value of horticultural crops per ha (million IDR/ha) (1)	Total value of staple crops per ha (million IDR/ha) (2)	Total value of estate crops per ha (million IDR/ha) (3)	Wage income per ha (million IDR/ha) (4)	Net Effect on agricultural output per ha (million IDR/ha) (5)	Total net effect (million IDR/ha) (6)
Diversification (% horticultural land)	0.4189**	-0.1798***	-0.0323	-0.2165	0.2068	-0.0097
	(0.1627)	(0.0465)	(0.0602)	(0.1322)		
Age HH (years)	-0.0649	-0.0054	-0.1184	-0.4564**		
	(0.0453)	(0.0654)	(0.0848)	(0.1845)		
Education HH (years)	-0.1099	-0.0301	-0.0555	0.7853		
	(0.1377)	(0.2284)	(0.2948)	(0.6432)		
Number of adult aged between 16-65	-0.1295	-0.4296	-0.7118	5.1723**		
	(0.4798)	(0.7265)	(0.9475)	(2.0804)		
Mobile phone ownership (unit)	0.4168	0.4060	0.9462	2.7542		
	(0.4169)	(0.6635)	(0.8614)	(1.8913)		
Transportation asset (million Rp)	-0.0082	0.0320	0.0873**	0.1576*		
	(0.0202)	(0.0329)	(0.0429)	(0.0940)		
Production asset (million Rp)	0.1037	0.4982***	0.9539***	-0.4410		
	(0.1055)	(0.1734)	(0.2259)	(0.4940)		
Storage asset (million Rp)	0.0094	0.0188	-0.0235	0.0308		
	(0.0243)	(0.0356)	(0.0461)	(0.1013)		
Farm size (ha)	-0.9940	-3.3942***	-2.2721*	-14.230***		
	(0.6483)	(0.9046)	(1.1722)	(2.5709)		
% of rented land	0.0197	-0.0820***	-0.0118	-0.1091		
	(0.0255)	(0.0233)	(0.0303)	(0.0665)		
% of irrigated land	0.0239**	0.1599***	-0.0509**	-0.0460		
	(0.0121)	(0.0162)	(0.0213)	(0.0460)		
Remittance income (million Rp)	0.0013	-0.0254	-0.0012	-0.0364		
	(0.0290)	(0.0472)	(0.0614)	(0.1349)		
Pension income (million Rp)	0.0310	-0.0817	0.1194	0.8086		
	(0.1121)	(0.1829)	(0.2380)	(0.5223)		

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 11. 3SLS results of the farm household income for all sample (cont.)

VARIABLES	Total value of horticultural crops per ha (million IDR/ha) (1)	Total value of staple crops per ha (million IDR/ha) (2)	Total value of estate crops per ha (million IDR/ha) (3)	Wage income per ha (million IDR/ha) (4)	Net Effect on agricultural value per ha (million IDR/ha) (5)	Total net effect (million IDR/ha) (6)
Distance to nearest urban market (km)	-0.0019	-0.0292	-0.1342**	-0.2676*		
	(0.0341)	(0.0501)	(0.0646)	(0.1416)		
Elevation (m)	-0.0042*	-0.0100***	0.0009	0.0025		
	(0.0022)	(0.0025)	(0.0032)	(0.0069)		
Member in farmer group (1/0)	1.6712	3.7294**	1.6520	-0.7941		
	(1.0975)	(1.7195)	(2.0757)	(4.5233)		
Horticultural farming experience (1/0)	-4.1112					
	(4.2206)					
FFS GAP/GHP (1/0)	2.5714					
	(1.6017)					
Received to extension support in horticulture production (1/0)	-0.7903					
	(1.9765)					
FFS ICM (1/0)		-3.0286**				
		(1.5396)				
Received to extension support in staple production (1/0)		2.9732**				
		(1.4234)				
Grain mill ownership (1/0)		1.0852				
		(1.6889)				
Received to extension support in estate crop production (1/0)			4.5542*			
			(2.6000)			
Constant	1.6005	15.6756***	15.0176**	41.9194***		
	(4.0216)	(5.1646)	(6.6628)	(14.5561)		
Observations	959	959	959	959		
Chi2	189.8***	274.52***	42.84***	84.9***		
R-squared	0.274	0.239	0.046	0.086		

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 12. 3SLS results of the farm household income in lowland areas

	Total value of horticultural crops per ha (million IDR/ha)	Total value of staple crops per ha (million IDR/ha)	Total value of estate crops per ha (million IDR/ha)	Wage income per ha (million IDR/ha)	Net Effect on agricultural output per ha (million IDR/ha)	Total net effect (million IDR/ha)
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Diversification (% horticultural land)	0.3019	-0.2130***	-0.1253***	-0.3114**	-0.0364	-0.3508
	(0.3355)	(0.0512)	(0.0463)	(0.1516)		
Age HH (years)	-0.0410	0.0939	-0.0592	-0.5805***		
	(0.0589)	(0.0700)	(0.0635)	(0.2077)		
Education HH (years)	-0.1996	0.2123	0.0245	0.0426		
	(0.1559)	(0.2279)	(0.2039)	(0.6670)		
Number of adult aged between 16-65	-0.5836	-0.1533	0.0026	5.8847***		
	(0.5947)	(0.7236)	(0.6601)	(2.1616)		
Mobile phone ownership (unit)	0.8413*	0.0728	0.7075	0.7846		
	(0.4758)	(0.6969)	(0.6316)	(2.0652)		
Transportation asset (million Rp)	0.0111	0.0263	0.0974***	0.1972**		
	(0.0208)	(0.0309)	(0.0281)	(0.0921)		
Production asset (million Rp)	0.1200	0.4561***	-0.0649	-0.1583		
	(0.1092)	(0.1601)	(0.1462)	(0.4764)		
Storage asset (million Rp)	0.0152	0.0211	-0.0137	0.0924		
	(0.0317)	(0.0319)	(0.0289)	(0.0945)		
Farm size (ha)	-1.6626	-2.8491***	-0.2780	-13.577***		
	(1.1040)	(0.8732)	(0.7923)	(2.5865)		
% of rented land	0.0458	-0.0773***	0.0122	-0.0987		
	(0.0327)	(0.0217)	(0.0197)	(0.0647)		
% of irrigated land	0.0133	0.1444***	-0.0655***	-0.0609		
	(0.0195)	(0.0165)	(0.0150)	(0.0484)		
Remittance income (million Rp)	0.0018	-0.0288	0.0003	-0.0417		
	(0.0287)	(0.0423)	(0.0385)	(0.1261)		
Pension income (million Rp)	0.0002	-0.1791	0.1977	0.2185		
	(0.1271)	(0.1829)	(0.1666)	(0.5449)		

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 12. 3SLS results of the farm household income in lowland areas (cont.)

	Total value of horticultural crops per ha (million IDR/ha)	Total value of staple crops per ha (million IDR/ha)	Total value of estate crops per ha (million IDR/ha)	Wage income per ha (million IDR/ha)	Net Effect on agricultural value per ha (million IDR/ha)	Total net effect (million IDR/ha)
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Distance to nearest urban market (km)	-0.0193	-0.0271	-0.1240**	-0.3224*		
	(0.0419)	(0.0566)	(0.0511)	(0.1674)		
Member in farmer group (1/0)	0.8759	2.6973	1.7731	0.2380		
	(1.1046)	(1.7237)	(1.4823)	(4.8385)		
Horticultural farming experience (1/0)	0.2131					
	(8.1843)					
FFS GAP/GHP (1/0)	2.9815					
	(2.4246)					
Received to extension support in horticulture production (1/0)	3.8082					
	(4.6664)					
FFS ICM (1/0)		0.7452				
		(1.6327)				
Received to extension support in staple production (1/0)		1.8307				
		(1.4525)				
Grain mill ownership (1/0)		0.9296				
		(1.4932)				
Received to extension support in estate crop production (1/0)			4.1467*			
			(2.3670)			
Constant	2.2751	9.6083*	10.8025**	55.6947***		
	(5.7138)	(5.4604)	(4.9270)	(16.1345)		
Observations	690	690	690	690		
Chi2	209.7***	209.8***	48.24***	73.02***		
R-squared	0.354	0.252	0.063	0.099		

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 13. 3SLS results of the farm household income in highland areas

VARIABLES	Total value of horticultural crops per ha (million IDR/ha) (1)	Total value of staple crops per ha (million IDR/ha) (2)	Total value of estate crops per ha (million IDR/ha) (3)	Wage income per ha (million IDR/ha) (4)	Net Effect on agricultural output per ha (million IDR/ha) (5)	Total net effect (million IDR/ha) (6)
Diversification (% horticultural land)	0.1653	-0.0757	0.0332	0.0696	0.0576	0.1272
	(0.1773)	(0.1062)	(0.1422)	(0.2795)		
Age HH (years)	-0.2010***	-0.2663*	-0.0945	-0.0260		
	(0.0721)	(0.1546)	(0.2029)	(0.3943)		
Education HH (years)	0.1256	-0.5495	1.0298	4.5616**		
	(0.3193)	(0.6839)	(0.9131)	(1.7870)		
Number of adult aged between 16-65	-0.3112	-0.8373	-0.4569	6.5473		
	(0.9725)	(2.0270)	(2.7122)	(5.3788)		
Mobile phone ownership (unit)	-0.3781	-0.3116	-0.6964	8.5564*		
	(0.8313)	(1.6480)	(2.2065)	(4.3781)		
Transportation asset (million Rp)	-0.1117*	0.0633	-0.1216	-0.1141		
	(0.0590)	(0.1245)	(0.1662)	(0.3298)		
Production asset (million Rp)	-0.1369	0.3980	14.0431***	-2.2444		
	(0.3887)	(0.7981)	(1.0611)	(2.1046)		
Storage asset (million Rp)	0.2999	-0.2926	0.2699	-0.8890		
	(0.3497)	(0.7354)	(0.9779)	(1.9420)		
Farm size (ha)	-0.2018	-6.4167**	-8.3557**	-18.3773**		
	(1.4335)	(3.0150)	(4.0174)	(7.9772)		
% of rented land	-0.0034	-0.1299	-0.0998	-0.1933		
	(0.0930)	(0.0996)	(0.1349)	(0.2635)		
% of irrigated land	0.0446**	0.1894***	-0.0698	0.0332		
	(0.0212)	(0.0440)	(0.0589)	(0.1155)		
Remittance income (million Rp)	-0.0201	0.1446	0.0762	-0.5063		
	(0.1732)	(0.3665)	(0.4890)	(0.9710)		
Pension income (million Rp)	0.0195	0.2172	-0.1288	2.6866**		
	(0.2319)	(0.4949)	(0.6554)	(1.3013)		

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 13. 3SLS results of the farm household income in highland areas (cont.)

VARIABLES	Total value of horticultural crops per ha (million IDR/ha) (1)	Total value of staple crops per ha (million IDR/ha) (2)	Total value of estate crops per ha (million IDR/ha) (3)	Wage income per ha (million IDR/ha) (4)	Net Effect on agricultural value per ha (million IDR/ha) (5)	Total net effect (million IDR/ha) (6)
Distance to nearest urban market (km)	-0.0080	-0.0473	-0.0677	-0.2725		
	(0.0509)	(0.1023)	(0.1330)	(0.2614)		
Member in farmer group (1/0)	0.6139	7.7360*	-1.3914	-5.9859		
	(2.5142)	(4.6206)	(5.6290)	(11.0491)		
Horticultural farming experience (1/0)	0.0217					
	(5.0098)					
FFS GAP/GHP (1/0)	2.3059					
	(2.4771)					
Received to extension support in horticulture production (1/0)	-1.5600					
	(1.9673)					
FFS ICM (1/0)		-7.2492**				
		(3.6306)				
Received to extension support in staple production (1/0)		8.0550**				
		(3.6479)				
Grain mill ownership (1/0)		15.7544				
		(17.8428)				
Received to extension support in estate crop production (1/0)			4.1267			
			(4.8142)			
Constant	9.9025	22.3846*	9.8334	-18.6023		
	(6.8240)	(13.0950)	(17.3084)	(33.8355)		
Observations	269	269	269	269		
Chi2	36.41***	55.52***	186.11***	38.37***		
R-squared	0.227	0.181	0.407	0.122		

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 14. First stage results of horticultural crop diversification for the six systems of equations

	Diversification	Diversification	Diversification	Diversification	Diversification	Diversification
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Age HH (years)	-0.0967*	-0.0958	0.0274	-0.0965*	-0.0951	0.0151
	(0.0569)	(0.0622)	(0.1253)	(0.0569)	(0.0622)	(0.1255)
Education HH (years)	0.1446	0.1863	0.0257	0.1437	0.1897	-0.0608
	(0.1995)	(0.2036)	(0.5570)	(0.1995)	(0.2037)	(0.5581)
Number of adult aged between 16-65	-1.1618*	-1.0372	-1.3464	-1.1668*	-1.0353	-1.4011
	(0.6262)	(0.6420)	(1.6166)	(0.6262)	(0.6420)	(1.6177)
Mobile phone ownership (unit)	0.7567	0.4052	1.9006	0.7717	0.4100	1.9260
	(0.5729)	(0.6203)	(1.3052)	(0.5732)	(0.6204)	(1.3059)
Transportation asset (million Rp)	0.0120	0.0058	0.0321	0.0119	0.0056	0.0383
	(0.0287)	(0.0275)	(0.1005)	(0.0287)	(0.0276)	(0.1006)
Production asset (million Rp)	-0.0371	0.0348	-0.5064	-0.0304	0.0412	-0.5102
	(0.1511)	(0.1433)	(0.6490)	(0.1512)	(0.1433)	(0.6496)
Storage asset (million Rp)	0.0658**	0.0691**	0.2933	0.0670**	0.0697**	0.2457
	(0.0310)	(0.0284)	(0.5977)	(0.0310)	(0.0284)	(0.5984)
Farm size (ha)	-1.8974**	-2.6418***	0.6586	-1.8731**	-2.6308***	0.7918
	(0.7917)	(0.7888)	(2.4538)	(0.7925)	(0.7889)	(2.4554)
% of rented land	0.1269***	0.0859***	0.4527***	0.1270***	0.0857***	0.4584***
	(0.0194)	(0.0187)	(0.0683)	(0.0194)	(0.0187)	(0.0683)
% of irrigated land	-0.0467***	-0.0455***	-0.0346	-0.0457***	-0.0442***	-0.0334
	(0.0137)	(0.0143)	(0.0355)	(0.0138)	(0.0143)	(0.0356)
Remittance income (million Rp)	-0.0235	-0.0164	-0.0134	-0.0230	-0.0163	-0.0201
	(0.0410)	(0.0377)	(0.2961)	(0.0410)	(0.0377)	(0.2963)
Pension income (million Rp)	-0.1166	-0.1243	-0.0384	-0.1206	-0.1266	-0.0234
	(0.1589)	(0.1630)	(0.3994)	(0.1590)	(0.1630)	(0.3999)

Notes: Coefficient estimates are shown with standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. (1)-(6) refer to the first stage results of diversification for for the six systems of equations as follows: (1)the value of food supply for all sample; (2) the value of food supply for all sample in highland areas; (3) the value of food supply for all sample in lowland areas; (4) the farm household income for all sample; (5) the farm household income in highland areas; and (6) the farm household income in lowland areas.

Appendix 14. First stage results of horticultural crop diversification for the six systems of equations (cont.)

VARIABLES	Diversification (1)	Diversification (2)	Diversification (3)	Diversification (4)	Diversification (5)	Diversification (6)
Distance to nearest urban market (km)	-0.0768*	-0.0430	-0.0829	-0.0752*	-0.0400	-0.0901
	(0.0437)	(0.0508)	(0.0827)	(0.0437)	(0.0508)	(0.0829)
Elevation (m)	0.0120***			0.0118***		
	(0.0021)			(0.0021)		
Member in farmer group (1/0)	-1.2869	0.6489	-4.8802	-1.1716	0.7545	-5.3383
	(1.4897)	(1.5382)	(3.6663)	(1.4972)	(1.5395)	(3.6769)
Horticultural farming experience (1/0)	25.1806***	24.0337***	27.0284***	25.2059***	24.0783***	26.8665***
	(1.3404)	(1.4627)	(2.8497)	(1.3409)	(1.4666)	(2.8523)
FFS GAP/GHP (1/0)	6.0284***	6.2862***	4.7201	6.1022***	6.6337***	3.8756
	(2.1118)	(2.3467)	(4.2796)	(2.1330)	(2.3634)	(4.2935)
Received to extension support in	12.5996***	14.5985***	8.3493***	12.5687***	14.5164***	7.9739**
horticulture production (1/0)	(1.7586)	(2.0939)	(3.1338)	(1.7578)	(2.1056)	(3.1437)
FFS ICM (1/0)	-2.0462	-2.1384	-3.1912	-2.3128	-2.5080	-2.0631
	(1.2765)	(1.5587)	(3.0004)	(1.4405)	(1.5871)	(3.0864)
Received to extension support in staple	-2.9176**	-1.6034	-9.4682***	-3.1345**	-1.7974	-10.3187***
production (1/0)	(1.1952)	(1.3725)	(3.0479)	(1.3148)	(1.3989)	(3.0638)
Grain mill ownership (1/0)	1.0085	0.6127	-7.3666	0.5618	0.3081	-6.6927
	(1.2598)	(1.3107)	(13.9116)	(1.4638)	(1.3451)	(14.3332)
Received to extension support in estate	-4.8345***	-1.8332	-0.1846	-4.1892**	-0.7833	1.4452
crop production (1/0)	(1.6275)	(2.3405)	(3.0605)	(1.8239)	(2.3905)	(3.1497)
Constant	12.9121***	12.0276**	15.8878	12.8863***	11.8636**	17.4559*
	(4.4202)	(4.8047)	(10.2642)	(4.4198)	(4.8054)	(10.2862)
Observations	959	690	269	959	690	269
Chi2	896.9***	642.88***	245.76***	896.63***	642.87***	245.8***
R-squared	0.483	0.482	0.477	0.483	0.482	0.476

Notes: Coefficient estimates are shown with standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. (1)-(6) refer to the first stage results of diversification for for the six systems of equations as follows: (1)the value of food supply for all sample; (2) the value of food supply for all sample in highland areas; (3) the value of food supply for all sample in lowland areas; (4) the farm household income for all sample; (5) the farm household income in highland areas; and (6) the farm household income in lowland areas.

Appendix 15. Farm household questionnaire

SURVEY OF FARMERS' ADOPTION IN JAVA

February - March 2013

IFPRI - UNIVERSITY OF ADELAIDE - CAPAS

Objective: The purpose of this survey is to improve our understanding of problems and opportunities of horticultural crop production in Indonesia, particularly to address smallholder participation in value chain for horticultural crops

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		

		Code in A1
Name of head family		
Name of respondent		
Address/location		
Phone		
Village		
Sub-district		
District		

Introduction

Hello, my name is ___________________. I work for the CAPAS and we are carrying out a survey of farmers in Java. The survey is intended to understand the problems and opportunities of horticultureal crop production. Your household is one of 960 households that have been selected to participate. The results are confidential and will only be used for research purposes. We would like about 3 hours of your time to ask you some questions.

	Date			Name	Sign
	Day	Month	Year		
Interview			2013		
Field check			2013		
Cross Edit Check			2013		
Data Entry			2013		

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

Village Code

Enumerator Code

West Java - Districts Subang

Code	Sub-district	Village
111	Blanakan	Rawamekar
112	Blanakan	Jayamukti
113	Blanakan	Langensari
114	Blanakan	Tanjungtiga
121	Purwadadi	Wanakerta
122	Purwadadi	Parapatan
123	Purwadadi	Purwadadi Barat
124	Purwadadi	Panyingkiran
131	Ciater	Nagrak
132	Ciater	Cibitung
133	Ciater	Palasari
134	Ciater	Cisaat
141	Kasomalang	Pasanggrahan
142	Kasomalang	Bojangloa
143	Kasomalang	Sukamelang
144	Kasomalang	Kasomalang Kulon

Central Java - Districts Demak

Code	Sub-district	Village
311	Dempet	Kuwu
312	Dempet	Botosengon
313	Dempet	Gempoldenok
314	Dempet	Kedungori
321	Wonosalam	Bunderan
322	Wonosalam	Pilangrejo
323	Wonosalam	Mojodemak
324	Wonosalam	Kuncir
331	Mijen	Mlaten
332	Mijen	Bermi
333	Mijen	Pasir
334	Mijen	Pecuk
341	Karangawen	Wonosekar
342	Karangawen	Teluk
343	Karangawen	Rejosari
344	Karangawen	Brambang

East Java - Districts Jombang

Code	Sub-district	Village
511	Diwek	Bulurejo
512	Diwek	Cukir
513	Diwek	Brambang
514	Diwek	Bandung
521	Kesamben	Jombok
522	Kesamben	Pojokrejo
523	Kesamben	Kedungmlati
524	Kesamben	Jatiduwur
531	Ngoro	Genukwatu
532	Ngoro	Kesamben
533	Ngoro	Gajah
534	Ngoro	Badang
541	Sumobito	Talunkidul
542	Sumobito	Palrejo
543	Sumobito	Kendalsari
544	Sumobito	Mentoro

Kode	Enumerator
01	Pitriati Solihah
02	Atin Supriatin
03	Usep Santosa
04	Fajar Hariyanto
05	Fazmi Nawafi
06	Ruhmaniyati
07	Temberyanto Setiawan
08	Cirama Buari
09	Aziz Kurniawan
10	Wahyu Kurniawan
11	Danny Ardiansyah
12	Erick S Mubarok
13	Dewi Amna
14	Inneke Kumalasanti
15	Riyan Hidayat
16	Mawardi
17	Velin Lamuningtyas
18	Waluyo

West Java - Districts Tasikmalaya

Code	Sub-district	Village
211	Cineam	Cikondang
212	Cineam	Nagaratengah
213	Cineam	Madiasari
214	Cineam	Ancol
221	Manonjaya	Margaluyu
222	Manonjaya	Pasirbatang
223	Manonjaya	Cihaur
224	Manonjaya	Margahayu
231	Sodonghilir	Cikalong
232	Sodonghilir	Pakalongan
233	Sodonghilir	Sepatnunggal
234	Sodonghilir	Cukangkawung
241	Sukahening	Sundakerta
242	Sukahening	Kiarajangkung
243	Sukahening	Calincing
244	Sukahening	Banyurasa

Central Java - Districts Rembang

Code	Sub-district	Village
411	Kaliori	Meteseh
412	Kaliori	Banggi
413	Kaliori	Sendangagung
414	Kaliori	Babadan
421	Pamotan	Ringin
422	Pamotan	Gambiran
423	Pamotan	Sidorejo
424	Pamotan	Japerejo
431	Sedan	Pacing
432	Sedan	Sidomulyo
433	Sedan	Gandirejo
434	Sedan	Jambeyan
441	Kragan	Ngasinan
442	Kragan	Mojokerto
443	Kragan	Tegalmulyo
444	Kragan	Woro

East Java - Districts Tulungagung

Code	Sub-district	Village
611	Campurdarat	Sawo
612	Campurdarat	Campurdarat
613	Campurdarat	Pelem
614	Campurdarat	Tanggung
621	Kedungwaru	Ringinpitu
622	Kedungwaru	Kedungwaru
623	Kedungwaru	Majan
624	Kedungwaru	Tapan
631	Rejotangan	Tenggong
632	Rejotangan	Sukorejowetan
633	Rejotangan	Pakisrejo
634	Rejotangan	Tenggur
641	Pagerwojo	Mulyosari
642	Pagerwojo	Samar
643	Pagerwojo	Pagerwojo
644	Pagerwojo	Gambiran

A. CHARACTERISTICS OF MEMBERS OF THE HOUSEHOLD

	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 Other related 8 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] Nbr of years	Ask these questions only for members 6 years or older: How many years of schooling has [name] completed? Nbr of years	Can [name] read in any language? 1 Yes 2 No	Can [name] speak Bahasa? 1 Yes 2 No	Ask tthese questions only for members 15 yrs and older: What is the marital status of [name]? 1 Single 2 Married 3 Widowed 4 Separated 5 Divorced	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. Unemployed 7. Unpaid housework 8. Student 9. Other 10. None (for A10) Main	Secondary
A1		A2	A3	A4	A5	A6	A7	A8	A9	A10
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 unless a new member (baby or new in-law)
The head of the household is defined as the member who makes most of the economic decisions.

B. HOUSING

What is the approximate area of your house and yard in square meters? B1

[If house owned] What is the approximate value of your house without farmland? B2a

[If house rented] What is the annual rent that you pay for your house (without farmland)? B2b

What is the main source of drinking water for your household? B3

1 Indoor tap
2 Outdoor private tap
3 Outdoor shared tap
4 Covered well
5 Collected rainwater
6 River, lake, or pond
7 Spring
8 Aqua/bottled water
9 Other

What is the main type of toilet used by your household? B4

1 Flush toilet
2. Latrine with pipe
3 Pit latrine
4 Latrine over water
5 Public toilet (all types)
6 Other or none

What is the main type of lighting used by your household? B5

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

What type of fuel is used by your household for cooking? B6

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

What is the distance in meters from the house to the nearest...

...road of any type? B7
...asphalt road? B8
...market? B9
...district or city market? B10

C. ASSETS

	How many of each of the following asset did your household own five years ago? Number		How many of each does your household currently own? Number		What is the current value of each asset? [Rp]	
a radio?		C1a		C1b		
television?		C2a		C2b		
a fan?		C3a		C3b		
an air conditioner?		C4a		C4b		
a computer?		C5a		C5b		
a washing machine?		C6a		C6b		
a refrigerator?		C7a		C7b		
landline telephone?		C8a		C8b		
a mobile phone?		C9a		C9b		
internet (0=no, 1=yes)		C10a		C10b		
a bicycle?		C11a		C11b		
a motorbike?		C12a		C12b		
a car?		C13a		C13b		
a truck?		C14a		C14b		C14c
a tossa?		C15a		C15b		C15c
a cart?		C16a		C16b		C16c
a water pump for ag?		C17a		C17b		C17c
spraying equipment?		C18a		C18b		C18c
a tractor or hand tractor?		C19a		C19b		C19c
a storage house?		C20a		C20b		C20c
a grain mill?		C21a		C21b		C21c
cattle/buffalo?		C22a		C22b		
goats/sheep?		C23a		C23b		
poultry?		C24a		C24b		

	Area	Unit code	Area	Unit
farm land?	C25a	C25u	C26a	C26u
irrigated farm land?	C27a	C27u	C28a	C28u

1 Hectare
2 Bau
3 Bata
4. Tumbak
5. Ru
6. M2
7. Patok

D. AGRICULTURAL LAND

	1. Yes 2. No		Value (Rp)	Area	Area unit	1 Hectare		1 Yes 2 No
Have you **purchased** farm land over the past 5 years?	D1	If yes, how much land did you buy and what was the total value?	D2v	D2a	D2u	2. Bau 3 Bata 4. Tumbak	Purchase from family?	D2f
Have you **sold** farm land over the past 5 years?	D3	If yes, how much land did you sell and what was the total value?	D4v	D4a	D4u	5. Ru 6. M2 7. Patok	Sale to family?	D4f

Draw a simple map of the CROP land **owned or farmed** by members of the household in 2011-12 on the opposite page. Then number plots and complete this form.

Plot nbr	What is the area of this plot? Area	What is the area of this plot? Unit	What type of land is this?	What is the **current** land tenure arrangment for this plot?	What is the distance from this plot to your house?	[If D8=1-6] When was this plot acquired?	[If D8=1-6] How was this plot acquired?	What type of irrigation does this plot have in the … RAINY season	What type of irrigation does this plot have in the … DRY season
		1 Hectare 2 Bau 3 Bata 4. Tumbak 5. Ru 6. M2 7. Patok	1.Technical Irrigated 2.Semi-Tech Irrigated 3. Simple Irrigated 4. Rainfed 5. Dryland 6. Forest	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 11. Now, not farmed or owned	Distance in meters	Year [e.g 2007]	1 Inherited 2 Gift 3 Purchased 4 Allocated by governmen	1 None 2 Gravity 3 Pumped surface water 4 Pumped groundwater 5. Manual	1 None 2 Gravity 3 Pumped surface water 4 Pumped groundwater 5. Manual
D5	D6a	D6u	D7	D8	D9	D10	D11	D12r	D12d
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

Note : In D8, Bengkok land is coded as 10

Crop codes

Category	Code	Crop
Grains	101	Rice
	102	Maize
	199	Other grains
Tubers	201	Cassava
	202	Sweet potato
	299	Other tubers
Pulses	301	Red bean
	302	Groundnuts
	303	Soybeans
	304	Mung bean
	399	Other beans/pulses
Vegetables	401	Babycorn
	402	Broccoli
	403	Cabbage
	404	Caisin/bok choi
	405	Carrot
	406	Chili
	407	Chinese cabbage
	408	Cucumber
	409	Eggplant
	410	Gherkin
	411	Ginger
	412	Green bean (buncis)
	413	Leek
	414	Lettuce
	415	Spinach
	416	Kangkung
	417	Onion
	418	Potato
	419	Shallot
	420	Spring onion
	421	String bean
	422	Tomato
	499	Other vegetable

Category	Code	Crop
Fruit	501	Avocado
	502	Banana
	503	Mango
	504	Mangosteen
	505	Melon
	506	Papaya
	507	Strawberry
	508	Watermelon
	509	Rambutan
	510	Jambu air
	511	Star fruit
	512	Pineapple
	513	Snack Fruit
	514	Duku
	599	Other fruit
Other	601	Flower
	602	Other spices
	603	Grass or forage crops
	604	Tea
	605	Coconut
	606	Sugarcane
	607	Tobacco
	608	Other annual crops
	699	Other perrenial crops

Back of page 3

E1. CROP PRODUCTION

Enumerator: Ask w hich crops w ere planted in each season from October 2011 to September 2012, then ask E4 to E8. This table is at the **CROP**-season level,NOT plot

Season			What crop w as planted during the [….] season? Crop code [see codes crops]	[enter PLOT numbers in w hich crop w ere grow n from part D for each section]										How much [crop] w as harvested from this plot during the […] season?		Who in the household has main responsibility for managing this crop? 1. Head of HH 2. Spouse 3. Other HH members	How good w as this harvest (2011 or 2012) compared to a normal year? 1 Higher 2 Same 3 Low er 4 Don't know / NA	[If E7=4 or 5] Why w as the harvest smaller than usual? 1 Too little rain 2 Too much rain 3 Insects 4. Disease 5. Natural Disaster 6 Poor inputs 7 Soil fertility 8 Other
				E4										Quantity	Unit 1. Kg 2 Kw intal 3 Ton 4 Liter 5. Tebasan			
	S	Row	E3	a	b	c	d	e	f	g	h	i	j	E5q	E5u	E6	E7	E8
Rainy season (planting about Oct 2011)	1	1																
	1	2																
	1	3																
	1	4																
	1	5																
	1	6																
	1	7																
	1	8																
	1	9																
	1	10																
Dry season (planting about March 2012)	2	1																
	2	2																
	2	3																
	2	4																
	2	5																
	2	6																
	2	7																
	2	8																
	2	9																
	2	10																
Dry season (planting about July 2012)	3	1																
	3	2																
	3	3																
	3	4																
	3	5																
	3	6																
	3	7																
	3	8																
	3	9																
	3	10																

Note: For crops w hich harvested all year (e.g coconut), record all information in the all season row s

For crops w hich harvested once a year (e.g mango, rambutan), record all information in the season row w here it w as harvested

Note: For mixed cropping or more than one crop in a plot, record plot number in more than one row and each crop in a separate row ,

Page 4

E2. Crop utilization

Enumerator: This table is at the crop level, not plot level, for each season.

If there were sales (E10u=5 or E14>0), ask E16 to E22

Planting season	S	Row	Crop codes Write each crop code from E3	How much [crop] was harvested in the [season]? Quantity (can be copied from E5q)	Unit 1. Kg 2 Kwintal 3 Ton 4 Liter 5.Tebasan	How much of this was consumed by the household?	How much was saved for seed? [G5=0 for cassava, plantain..]	How much was saved for NON-seed? [e.g stock..]	How much was sold?	How much was used for gifts, losses, exchange, processing, etc?	What TOTAL VALUE did you receive when selling this crop? Rp	When were you paid for the [..] harvest? 1. Before harvest 2. At delivery/sale 3. 1-7 days later 4. > week later 5. Multiple payments (across categories)	What was the main PLACE where the [crop] was sold? 1 On farm or home 2 Market in village 3 Mkt outside village 4 Road side 5 At cooperative 6 At processor/mill 7 Other	Who was the main type of BUYER of [crop]? 1 Farmer/ Consumer 2 Trader 3 Processor 4 Other	Did the buyer contract the household to grow [crop]? 1 Yes,Written 2 Yes,Oral 3 No	What is the distance from the farm to the main selling place? (meter)	[If not at farm and 100% hired transport] How much did it cost to transport it from the field to the point of sale? [0 if no cash cost] Rp
						Quantity (note: quantity in same unit as in E10u)											
	S	Row	E9	E10q	E10u	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	E21	E22
Rainy season (planting about Oct 2011)	1	1															
	1	2															
	1	3															
	1	4															
	1	5															
	1	6															
	1	7															
	1	8															
	1	9															
	1	10															
Dry season (planting about March 2012)	2	1															
	2	2															
	2	3															
	2	4															
	2	5															
	2	6															
	2	7															
	2	8															
	2	9															
	2	10															
Dry season (planting about July 2012)	3	1															
	3	2															
	3	3															
	3	4															
	3	5															
	3	6															
	3	7															
	3	8															
	3	9															
	3	10															

Note: Verify that the total harvest (E10q) equal to the sum of different uses (E11+E12+E13+E14+E15).

F1. CROP INPUTS: SEED AND FERTILIZER **Page. 6**

Enumerator: Copy each unique crop code from E3 into F2 following th order: rice, secondary crop, and other three main crops based on area, then complete F3 to F25.

This table is at the CROP level over a year 2011-12, NOT plot/season level

	From E3, copy each unique crop over a year following the order: - Rice - Secondary crop - Other three main crops (based on area)	For the [crop] grown in [this year Wet season 2011 into Dry season 2 2012], how much ... did this household use?														[If F4q>0] What type of seed did you use?	Was any seed or fertilizer provided on credit to this household for [crop]?	[If F13 = 1 or 2 or 3], Who provided these inputs on credit?	[If F13= 1 or 2 or 3], Were you required to sell all or part of the harvest to the provider?
		...seed saved		…purchased seed			..manure, organic fertilizer		..chemical fertilizer: Urea, SP-36, ZA, NPK		..other fertilizer (e.g. liquid fertilizer, *pupuk majemuk*)	… chemical - pesticides, herbicides, & spraying services …	… bio - pestisida, herbisida, & other spraying services…	...tractor hire or animal..	......other crop inputs..				
		Quantiy	Unit	Quantiy	Unit	Value	Quantiy	Value	Quantiy	Value									
			see codes		see codes	(Rp)	(Kg)	(Rp)	(Kg)	(Rp)	Value (Rp)	Value (Rp)	Value (Rp)	Value (Rp)	Value (Rp)	see codes	see codes	see codes	see codes
F2r	F2	F3q	F3u	F4q	F4u	F4v	F5q	F5v	F6q	F6v	F7v	F8	F9	F10	F11	F12	F13	F14	F15
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			

Note: For fertilizer, if the response is given in bags, please convert to kg. A standard fertilizer bag is 50 kg.

Code for F3u&F4u
1. Gr
2. Kg
3 Seeds (*Bibit)*
4. Cutting (*Stek*)
5. Other

Code for F12
1 Hybrid
2 Certified
3 Both
4 Other

Code for F13
1 Yes, seed
2 Yes, fertilizer
3 Yes, both
4 Neither, >> next row

Code for F14	
1 Neighbour/Farmer	6. Seed company
2. Farmer group	7. NGO
3. Cooperative	8. Government/Dinas
4. Input dealer	9. Bank
5. Trader	10. Other

Code for F15
1.Yes, all
2.Yes, part
3. No

F2. CROP INPUTS: HIRED AND EXCHANGE LABOR

Enumerator: Copy each unique crop code from F2 into F16, then complete F17 to F30.

This table is at the CROP level over a year 2011-12, NOT plot/season level

	Crop Codes	Were the hired and or exchange labor to grow this crop [..]	For the [crop] grown in [this year Wet season 2011 into Dry season 2 2012], how many person-days of HIRED AND EXCHANGE LABOR were used on [activity] ?									From the activities from F18 to F26, How much of this labor was female?	From the activities from F18 to F26, How much of this labor was exchange labor?	What was the average daily wage paid to the hired laborers from F18-F26 activities (cash and in-kind)?		If there were other labor costs not counted in F18-F26, what was the total amount spent on this crop? (e.g. *borongan, bawon*)
	Write each crop code from **F2**		land preparation	planting	fertilizing	weeding	spraying	watering	harvesting	post harvest handling	others (e.g. mulching, *pengajiran*)			Male	Female	
		see codes	person-days									see code	see code	Rp per day per worker		Rp
F16r	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28	F29a	F29b	F30
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																

Note: Person-days are calculated as the number of workers times the number of days they worked. For example, if 5 people work for 3 days and 2 people continue for 6 more days, the total number of person-days is 5x3 + 2x6 = 27.

Number of workers		Number of days worked by each		Person-days
	x		=	
	x		=	

Note: F18-F26 includes both hired labor and exchange labor but excludes labor hired by someone who bought crop in the field (*tebasan*).
Do not record same payments in both F18-F26 and F30.

Code for F17
1. Yes, hired labor
2. Yes, exchange labor
3 Yes, both
4. Neither, >> F30
5. Yes, hired or exchanged but not in detail, >> F30

Code for F27
1. All
2. Most
3. Half
4. Some
5. None

Code for F28
1. All (>>F30)
2. Most
3. Half
4. Some
5. None

G1. POST HARVEST HANDLING

Enumerator: This table is at the crop level at E3, NOT plot level, NOT for each season.

	Crop codes Write each crop code from F2	Did you do any postharvest handling activities for this [crop]? 1. Yes 2.No, >> next row	When did you start post harvest handling for this [crop]? Year	If any postharvest activities, w hat type of postharvest handling did you do for this [crop],over the last year? (1. Yes, 2. No) sorting	grading	drying	cleaning	packaging	others	Why did you do these post harvest handling [G4a- G4f] for this [crop]? 1. Price premium 2. Buyer request 2. Learn from extension 4. Other	Compare to 5 years ago, how many type of these post harvest activities for this [crop]? 1. More 2. Same 3. Less 4. NA [e.g just start)	What is premium price for these activities [**G4a- G4f**] ? 1. 0% 2. 1-5% 3. 6-10% 4. 11-15% 5. >15% 6. NA (e.g not sold),
	G1	G2	G3	G4a	G4b	G4c	G4d	G4e	G4f	G5	G6	G7
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

G2. CROP MARKETING

Enumerator: This table is at the crop level over a year 2011-12, NOT plot level, NOT for each season.

	Crop codes — Write each crop code from F2	Over the last year, did you sell this [crops]? 1. Yes 2. No, >> next row	How many different crop buyers do you usually [.....] speak to about the sales of this [crop] last year? (person)	How many different crop buyers do you usually [.....] sell your [crop] to last year? (person)	When in the crop production cycle do you usually first communicate with a buyer? see code	How do you usually communicate with your crop buyer(s)? see code	When in the crop production cycle do you usually agree on the sale with the buyer? see code	Do you usually have **an agreement** with this crop buyer? 1. Yes, written 2. Yes, oral 3. No	If G14= 1 or 2, What are most specified in the agreement with the buyer? see code	see code	see code	Jika G14= 1 or 2, Has the level of detail in your agreements at G15a-c with this [crop] buyers changed compared to five (or more) years ago? see code	Do you negotiate with this [crop] buyer over the price? see code	Has your price bargaining postion with this [crop] buyers changed compared to five (or more) years ago? see code	Beside prices, do you negotiate with your this [crop] buyer over non-price terms of the agreement [e,g, quantity]? see code	Has your non-price bargaining position with this [crop] buyers changed compared to five (or more) years ago? see code
	G8	G9	G10a	G10b	G11	G12	G13	G14	G15a	G15b	G15c	G16	G17	G18	G19	G20
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																

Code for G11
1, Before planting
2. Between planting & early stages of production
3, Close to harvest (ijon)
4. After the harvest begins

Code for G12
1. Mobile phone
2. Landline phone
3. Buyer comes to the farm
4. Buyer comes to farmer' house
5. Farmer goes to buyer's place
6. Meet buyer elsewhere
7. Through intermediary person
8. Through cooperative/group

Code for G13
1. Before planting
2. Between planting&harvest
3. 1-7 before harvest
4. After harvest begin
5. Only at time of sale

Code for G15a-G15c
1. Price
2. Quantity
3. Grade/quality
4. Variety
5. Time of payment
6. Seed provided on credit
7. Other inputs provided on credit

Code for G16
1. They've become MORE detailed
2. No change
3. They've become LESS detailed
4. Not applicable (e.g start to grow 1-4 years ago)

Code for G17
1. No, I always accept the price the buyer offers
2. Yes, I sometimes bargain over price with the buyer
3. Yes, I usually bargain over price with the buyer
4. No, I set the price and don't bargain.

Code for G18
1. I have MORE price bargaining power than I used to.
2. No change in price bargaining power.
3. I have LESS price bargaining power than I used to.
4. Not applicable (e.g. first time)

Code for G19
1. No, I always accept the non-price terms of agreement that the buyer offers
2. Yes, I sometimes bargain over non-price terms of the agreement.
3. Yes, I usually bargain over non-price terms of the agreement.
4. No, I set the non-price terms of the agreement and don't bargain.
5. Not applicable (e.g. no non-price terms in agreement)

Code for G20
1. I have MORE non-price bargaining power than I used to.
2. No change in price bargaining power.
3. I have LESS non-price bargaining power than I used to.
4. Not applicable (e.g. first time, no non-price terms in agreement)

G3. CROP MARKETING (cont.)

Enumerator: This table is at the crop level over a year 2011-12, NOT plot level, NOT for each season.

	Crop code	Copy the answer from G9	In the last year that you grew this crop, did your buyer provide [...]? seed	pesticide	other agricultural chemical	Information on how to produce [crop]?	inputs on credit	financial loan	Guarantee of a specific price before planting	Guarantee to purchase specific quantity	Have you had any problems with your [crop] buyer?	[If G30 = 1] What were the main problems ? (list up to three)			Did any of these problems (G31-G34) cause you to change your [crop] buyer?	Do you know what the end market for your [crop]? (e.g. Supermarket, trad market, processor)	[If G35=yes] How do you know what the end market of your [crop] is?	[If G35=yes] Are your [crop] eventually sold in any of the following type of markets? Traditional Market	Super-market	Processor	Exporter	Other modern market (e.g restoran)	Do you believe that your buyer requires higher or lower quality standards than other buyers ?	Do you believe that your buyer offers higher or lower prices than other buyers ?
	Write each crop code from F2	1 Yes 2. No, >> next row	1. Yes, 2. No								1. Yes 2. No, >> G35	see code			1. Yes 2. No	1. Yes 2. No, >> G42	see code	1. Yes, 2. No					see code	
G21r	G21a	G21b	G22	G23	G24	G25	G26	G27	G28	G29	G30	G31	G32	G33	G34	G35	G36	G37	G38	G39	G40	G41	G42	G43
1																								
2																								
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								

Code for G31-G33
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. Others

Code for G36
1. My first buyer /trader told me
2. I work or communicate directly with traders in end market
3. Heard from my neighbour/other farmers whos sold the product to the same buyer
4. Others

Code for G42-G43
1. Higher
2. Same
3. Lower
4. Don't know

H. 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? [ ] H1
...being sold to a processor? [ ] H2
... being exported? [ ] H3
...being sold to other modern markets? [ ] H3a

Do you know any farmers who have sold any **fruit or vegetables** that ended up ...?

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

...being sold in supermarkets? [ ] H4
...being sold to a processor? [ ] H5
... being exported fresh? [ ] H6
... being sold to other modern markets? [ ] H6a

[IF ALL ANSWERS, H1-H6a=3, GO TO SECTION I)
[IF ALL ANSWERS, H1-H6a=2, GO TO QUESTION H8]

[If H1 or H2 or H3 or H3a or H4 or H5 or H6 or H6a= yes] What has been their experience selling into these three modern channels? [ ] H7

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 modern channels? [ ] H8

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

What do you see as the main advantages of selling [ ] H9 [ ] H10 [ ] H11

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 modern channel
7. Don't know
8. Others

What factors do you think prevent farmers from selling into the modern channel? (up to 3) [ ] H12 [ ] H13 [ ] H14

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 and information
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 the product
11. Buyers don't pay immediately on delivery
12. Buyer require certification
13. Farmer not interested e.g. price, small demand
14. Don't know
15. Others

What do you think the government could do to help more farmers sell any crops into the modern channels? (up to 3) [ ] H15 [ ] H16 [ ] H17

1. Provide training in production methods
2. Provide training in grades & standards and marketing
3. Provide sustainability training and assistance
4. Guarantee price stabilization
5. Provide information on prices and markets
6. Improve supply of horticultural seed
7. Improve supply of agricultural chemicals
8. Invest in irrigation
9. Help organize farmers into groups
10. Improve roads in rural areas
11. Provide credit
12. Increase tax on imported agricultural products
13. Promote exports (e.g. reduce export tax & other costs)
14. Facilitate the access to modern retail market
15. Don’t know / no opinion
16. Others

I1. PRODUCTION AND MARKETING INFORMATION

Crops	Over the past 5 years, did you grow this [crop]? 1. Yes 2. No	If I2=1, ask question I2-I5 Since 2007, w hat have been your main sources of information about [crop] PRODUCTION METHODS ? (ask for up to 3 sources) see code			[For these 3 sources] How w ould you rate the quality of the production 1. Good 2. OK/Moderate 3. Poor			Sejak 2007, w hat have been your main sources of information about [crop] PRICES & (ask for up to 3 sources) see code			[For these 3 sources] How w ould you rate the quality of the price & market information? 1. Good 2. OK/Moderate 3. Poor		
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
I1	I2	I2a	I2b	I2c	I3a	I3b	I3c	I4a	I4b	I4c	I5a	I5b	I5c
Food crop													
Horticulture													
Estate crop													

Code for I2 and I4	
1. Extension w orkers	11.Cooperative
2. Research institute	12.Farmer group
3. DINAS & other govt institutions	13. NGO
4. Farmer/relative/neighbour	14.TV
5.Village leaders (formal & informal)	15. Radio
6.Trader	16.New spaper/magazine
7.Processor	17.Internet (w w w)
8.Input sellers	18.Mobile info service
9.Input companies	19.Other
10. Water use association (*P3A/HIPA*)	

I2. COLLECTIVE ACTION

	Did you or your family members ever join to any of the follow ing ? 1 Yes 2 No, >> next row	Do you/ your family members currently belong to any of the follow ing ? 1 Yes 2 No, >> next row	Did the group provide benefits in the follow ing activities? (1 Yes; 2 No; 3 Don't know) provision of inputs	hiring tractor	provision of credit	managing irrigation (sharing water)	Other tech assistance	planting	harvesting	post harvest handling	marketing	knowledge sharing	FFS-IPM	FFS-GAP/GHP	FFS-ICM	How satisfied are you / your family members w ith the group? 1.Very satisifed 2.Somew hat satisfied 3.Not satisfied	How has the performance changed compared to 2007? 1. Improved 2. No change 3. Worsened 4. Not applicable	Are there any sanctions for members w ho violate or don't run properly obligation? 1.Yes 2. No 3. Don't know	If I12=yes, w hat sanctions? 1. Lost membership privileges 2. Fine 3. Issued 4. Others
I6	I7	I8	I9a	I9b	I9c	I9d	I9e	I9f	I9g	I9h	I9i	I9j	I9k	I9l	I9m	I10	I11	I12	I13
1.*Sambatan (gotong royong)*																			
2. Farmer group																			
3. Water use association (*P3A/HIPA*)																			
4. Cooperative																			
5. Women Farmer's group																			
6. Other group																			

Note: FFS-IPM (Farmer Field School-Integrated Pest Management), FFS-GAP/GHP (FFS-*Good Agricultural Practices/Good Handling Practices*), FFS-ICM (FFS-Integrated Crop Management)

J1 FARMER ATTITUDINES AND PERCEPTIONS TOWARDS ADOPTION OF INNOVATIONS AND HORTICULTURAL CROPS

"We would like to explore farmer's beliefs and attitudes about adoption of innovations and **horticultural crops**. Adoption of innovations means adoption a new things such as crop/variety/production method to get a better result. Horticultural crops include vegetables, fruits, herbs and ornamental plants. I am going to read you several statements, then I would like you to tell me how strongly you agree or disagree with what I have said. 1=STRONGLY DISAGREE, 2=DISAGREE, 3=MODERATE, 4= AGREE and 5=STRONGLY AGREE. There is no right or wrong response - we are really just interested in getting your OPINION and BELIEFS. "

[Show respondent green "agreement" scale provided on card. Respondent should point to level of agreement]

1	I enjoy with new crop/variety/methods	☐	J 1
2	I prefer to use new crops/variety/methods that provide more profit	☐	J 2
3	I prefer to use new crops/variety/methods to improve my welfare	☐	J 3
4	I need access to market to produce new crops/variety or use new methods	☐	J 4
5	I need access to inputs to produce new crop/variety or use new methods	☐	J 5
6	Changing to new crops/variety/methods is easy and not overly costly	☐	J 6
7	Shifting to horticulture crops is risky	☐	J 7
8	Small farmers can NOT compete with large commercial farms in horticulture crops	☐	J 8
9	Shifting to horticulture crops need high initial investment / start-up cost	☐	J 9
10	Horticulture crops help me to improve my income	☐	J 10
11	Shifting to horticulture crops allow me to sell to supermarkets and other modern markets.	☐	J 11
12	The government should provides subsidies or incentives to plant horti crops	☐	J 12
13	Horticulture crops are more labor intensive than other crops	☐	J 13
14	Horticulture crops are more water intensive than other crops."	☐	J 14
15	Horticulture crops provide cash opportunities when needed (e.g flexible harvest)	☐	J 15

Which of the following two statements do you most agree with [enter 1 or 2]: 1 or 2 [ ] J19
1. "Each person is primarily responsible for his/her own success or failure in life"
2. "One's success in life is a matter of his/her destiny"

Which of the following two statements do you most agree with [enter 1 or 2]: 1 or 2 [ ] J20
1. "To be successful, above all one needs to work very hard"
2. "To be successful, above all one needs to be lucky"

For each of the following, please tell me if you 1 'strongly disagree', 2 'disagree', 3 'moderate', 4 'agree', or 5 'agree strongly'. 1,2,3, 4 or 5
"Most people can be trusted" [ ] J21
"I would trust my neighbors to look after my field if I had to travel for two months" [ ] J22

Imagine someone is going to give you some money, would you prefer: 1 or 2 [ ] J23
1. To be given 1 million Rp today or
2. To be given 1.25 million Rp after one month [>>J26]

[Ask if J23=1] In the same situation, would you prefer: 1 or 2 [ ] J24
1. To be given 1 million Rp today or
2. To be given 1.5 million Rp after one month [>> J26]

How much would you have to be given after one month for you to choose to wait rather than receive 1 million RP today? (> 1,5 million Rp) Rp [ ] J25

Would you prefer: 1 or 2 [ ] J26
1. To be given 1 million Rp after one month
2. To be given 1.25 million Rp after two months [>>J28]

[Ask if J26=1] Would you prefer: 1 or 2 [ ] J27
1. To be given 1 million Rp after one month
2. To be given 1.5 million Rp after two months [>>J28]

Imagine that you are going to market to sell a 100 kg bag of chili. 1,2,3,4, or 5
Which would you prefer: [ ] J28
1. To be certain you'll receive 250 thousand Rp for the bag?
2. To have an equal chance that you'll be paid 200 or 400 thousand Rp for the bag?
3. To have an equal chance that you'll be paid 150 or 550 thousand Rp for the bag?
4. To have an equal chance that you'll be paid 100 or 700 thousand Rp for the bag?
5. To have an equal chance that you'll be paid nothing or 1000 thousand Rp for the bag?

Imagine that someone you don't know is willing to give 1,000 thousand Rp. This person proposes to either give it all to you, or to share it with another member of your community, but you will not know which one, and this person will not know that it came from you. You get to decide how much to give to this other person. Which of the following do you choose? [ ] J29
1. You keep 1,000 thousand Rp and the other person gets 0
2. You keep 900 thousand Rp and the other person gets 100 thousand Rp
3. You keep 800 thousand Rp and the other person gets 200 thousand Rp
4. You keep 700 thousand Rp and the other person gets 300 thousand Rp
5. You keep 600 thousand Rp and the other person gets 400 thousand Rp
6. You keep 500 thousand Rp and the other person gets 500 thousand Rp
7. You keep 400 thousand Rp and the other person gets 600 thousand Rp
8. You keep 300 thousand Rp and the other person gets 700 thousand Rp
9. You keep 200 thousand Rp and the other person gets 800 thousand Rp
10. You keep 100 thousand Rp and the other person gets 900 thousand Rp
11. You keep 0 Rp and the other person gets 1,000 thousand Rp

K1. ADOPTION OF INNOVATIONS (NEW COMMODTIES/VARIETIES)

		1. Yes ; 2. No
Did you start growing any crop for the first time since 2007?	[ ]	K1a
Did you start growing any variety for the first time since 2007?	[ ]	K1b

If K1a=K1b=No, THEN SKIP TO SECTION K2.
If one of K1a or K1b =Yes OR both K1a&K1b = Yes, complete this following table and table on Section K1 (cont.)

No	List the crop or crop with new varieties codes of the most important new commodities [see crop code]	Since 2007, is this [crop] a new crop? 1. Yes 2. No	What year did you first grow the [crop]? [e.g. 2007]	What person/organization gave you the idea of adopting the [crop]? **[see code]**	What are the main reasons you decided to grow the [crop]? [max 2] **[see code]**		What kind of any assistance did you receive from [..] to grow the crop? **see code**				Are you still growing the [crop]? 1. Yes 2. No, >> K12	[If K9=1], area planted [..]				[If K9=2] What year did you stop growing the [crop]? e.g. 2011	[If K9=2] What are the main reasons you stopped growing the [crop]? **[see code]**	
							Govt.	Input comp.	processor	other		First time		2011/12				
												Area	unit **see code**	area	Unit **see code**			
K2	K3	K4	K5	K6	K7a	K7b	K8a	K8b	K8c	K8d	K9	K10a	K10b	K11a	K11b	K12	K13a	K13b
1																		
2																		
3																		
4																		
5																		
6																		

Note: If K4=No, it means that the farmers have adopted a new variety

Code for K6
1 Farmer/Neighbour
2 Extension officer
3 Trader
4 NGO
5 Dinas
6 Village leader formal/ informal)
7 Universities
8 Newspaper
9 Internet
10 Input companies
11 Input seller
12 Other

Code for K7a - K7b
1. To reduce costs of input/production
2. To reduce risk
3. To earn higher profit
4. To reduce labor use
5. To get more resistance to pest & disease
6. To get better unique characteristic (e.g taste, size, color)
7. To have shorter planting period
8. To earn higher yield
9. To follow market demand
10. To get more resistance to stress environment
11. Other

Code for K8a-K8d
1. Seed
2. Other input
3. Credit
4. Assistance/ training
5. No assistance/NA

Code for K11b
1 Hektar
2 Bau
3 Bata
4. Tumbak
5. Ru
6. M2
7. Patok

Code for K13a-K13b
1. Lack of information about production & marketing
2. Costs of obtaining information too high
3. Farm management too complicated
4. Cost of production higher than expected
5. Labour requirements excessive
6. Price of the crop lower than expected
7. Yield lower than expected due to pests and diseases
8. Yield lower than expected due to soil or climate
9. Benefits too far in the future
10. Limited availability of inputs
11. Other farmers recommend changing crops
12. Extension agent recommends changing crops
13. Other government officials recommend changing crops
14. Others

K1. ADOPTION OF INNOVATIONS (NEW COMMODTIES/VARIETIES) [cont.]

No	Write each crop code from K3	What w as the previous use of this land in the sequal season? 1 Rice 2 Secondary crop 3 Horticultural crop 4 Other crop 5 New rent 6 New purchase 7 Re-farmed	If K14b=1 or 2 or 3 or 4,Compare to the previous crop [K14b], does the new crop ...														[If K27=1],w hat is the new buyer for the [crop]?
			use more, less, or the same amount of …?													use different or the same of buyer?	
			Hired female labor	Hired male labor	Female family labor	Male family labor	Manure and organic fertilizer	Chemical fertilizer: Urea, SP-36, ZA, NPK	Other fertilizer (e.g. liquid fertilizer)	Chemical pesticide, herbicide, fungiside	Bio pesticide, herbicide, fungicide	Water use	Total input cost	Risk	Post harvest handling		
			1 More, 2 Same, 3 Less													1 Different 2 Same	see code
K14r	K14a	K14b	K15	K16	K17	K18	K19	K20a	K2b	K21	K23	K23	K24	K25	K26	K27	K28
1																	
2																	
3																	
4																	
5																	
6																	

K2. PERCEPTION OF WILLINGNESS TO ADOPT HORTICULTURAL CROPS

Are you interested in grow ing horticultural crop that you don't grow until now ? 1. Yes, 2 No [ ] K29

If K29=2, GO to Section K3

No	Write horti crop that you don't grow w ould you be most interested in grow ing? [max 2 crops] [see code crop]	What are the main reasons you don't grow [each crop]? [see code]		What are the important factors you need to formalize grow [each crop]? [see code]		
K30r	K30	K31a	K31b	K32a	K32b	K32c
1						
2						

Code for K32a-K32c		
1 Provision of seed	4 Production method assistan	7 Other tech assistance
2 Provision of other inputs	5 Post harvest assistance	8. Farmer field school
3 Provision of credit	6 Crop marketing assistance	

Code for K31a-K31b
1. Lack of information about production & marketing
2. Costs of obtaining information too high
3. Farm management too complicated
4. Cost of production higher than expected
5. Labour requirements excessive
6. Price of the crop low er than expected
7. Yield low er than expected due to pests and diseases
8. Yield low er than expected due to soil or climate
9. Benefits too far in the future
10. Limited availability of inputs
11. Land is good for rice
12.Land is good for secondary crops
13. Others

Code for K28
1. Trader/Collector
2. Wholesale buyer
3. Distributor
4. Processor
5. Exporter
6. Trader at main market
7. Supermarket
8. Consumers
9. Retailer

K3. ADOPTION OF INNOVATION (PRODUCTION METHODS)

			If K35=1, ask questions K36-K45									
	Production Methods	Since 2007, have you adopted the production method of [..]? 1. Yes 2. No, >> next row	What year did you start [..]? Year (e.g 2007)	Have you received the training in [..]? 1. Yes 2. No	What are the main reasons you adopted the [...]? [see code]		What crops are you grow ing using [...]? [w rite the 3 main crops based on area) [see crop code in section D]			Are you still using this method? 1.Yes 2. No	[If K43 = No] What are the main reasons you stopped using this method? [see code]	
K33	K34	K35	K36	K37	K38	K39	K40	K41	K42	K43	K44	K45
1	Application of organic & other non chemical fertilizer in land preparation											
2	Application of organic & other non chemical fertilizer in seedling											
3	Application of organic & other non chemical fertilizer during planting											
4	Direct seeding (*tabela*)											
5	Application of intermittent planting method (*jajar legowo*) to increase plant population											
6	Integrated pest management (to reduce pesticide use w ith bio-control/trap)											
7	Application of bio-pesticide											
8	Application of intermittent irigation (setting the land in dry & flooded conditions alternately)											
9	Integrated w eed control - w eeding w ith non chemical materials (e.g mechanical, mulch)											
10	Making irrigation from w ater tank											

Code for K38-K39 (reasons for adopting)

1. To reduce cost of inputs
2. To reduce risks
3. To earn higher prices for my products
4. New technology become available
5. See neighbors adopting w ith good results
6. Recommended by other farmers
7. Recommended by extension agent
8. Recommended by a trader or processor
9. Recommended by other government officials
10. To reduce health risk related to using chemicals
11. To reduce health risk of eating food w ith pesticide
12. To reduce health risk of consumers eating my products
13. To reduce negative impact on w ater and environment
14. To be able to access new markets
15. To take advantage of promotions by chemical vendors
16. To benefit from credit and other assistance programs
17 Take an initiative to implement after training
18 Others

Code for K44-K45 (reasons for discontinuing)

1. Lack of information about production & marketing
2. Costs of obtaining information too high
3. Farm management too complicated
4. Cost of production higher than expected
5. Labour requirements excessive
6. Price of the crop low er than expected
7. Yield low er than expected due to pests and diseases
8. Yield low er than expected due to soil or climate
9. Benefits too far in the future
10. Limited availability of inputs
11. Other farmers recommend stopping
12. Extension agent recommends stopping
13. Other government officials recommend stopping
14. Lack of government support or credit
15 Sharecroppers complained
16 Landlord complained
17 Others

L1. RECORD KEEPING

1. Yes 2. No

Do you keep written records on ….

… the amount of pesticides used on your crops?		L1
… the dates of pesticide application on your crops?		L2
… the prices received for your crops sales?		L3
… the quantities of your crops sold?		L4
... the input costs		L5

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

1. Yes 2. No

	L6

L2. DESIRED ATTRIBUTES ON ADOPTION

I am going to show you 11 cards with attributes that may be important when adopting a new crop or new farming system. In each case there will be 5 attributes shown, these will be different from one card to the next (total 11 cards). Please select one attribute that is MOST important to you when considering why you decided to adopt, and then select an attribute that is LEAST important to you. Please select only one of each.

CARD	A	B	C	D	E	F	G	H	I	J	K
Best											
Worst											
	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17

FOR EACH OF THE FOLLOWING QUESTIONS A-J Please choose the most and least important attributes when considering whether to adopt a new crop or new farming system.
Please tick one box in the left column to indicate the attribute that is MOST important to you and please tick one box in the right column to indicate the attribute that is LEAST important to you. Please tick only one box per column.

Question A

Most Important (tick one box)	Of the following, which attributes are the Most and Least important to you...	Least important (tick one box)
☐	1. High expected profit / return relative to other crops or systems	☐
☐	4. Good quality seeds are accessible	☐
☐	5. Less labour is required	☐
☐	9. Government provides subsidies or incentives to plant or change system	☐
☐	3. Stable and consistent yield (e.g. crop is resistent to weather, pests and disease)	☐

Question B

Most Important (tick one box)	Of the following, which attributes are the Most and Least important to you...	Least important (tick one box)
☐	2. Stable and consistent price	☐
☐	5. Less labour is required	☐
☐	6. Less water is required	☐
☐	10. Crop provides cash opportunities when needed (e.g. flexible harvest)	☐
☐	4. Good quality seeds are accessible	☐

Question C

Most Important (tick one box)	Of the following, which attributes are the Most and Least important to you...	Least important (tick one box)
☐	3. Stable and consistent yield (e.g. crop is resistent to weather, pests and disease)	☐
☐	6. Less water is required	☐
☐	7. Low initial investment / start-up costs	☐
☐	11. Training and assistance on how to produce or change system is accessible (easy to reach & affordable)	☐
☐	5. Less labour is required	☐

Question D

Most Important (tick one box)	Of the following, which attributes are the Most and Least important to you...	Least important (tick one box)
☐	4. Good quality seeds are accessible	☐
☐	7. Low initial investment / start-up costs	☐
☐	8. Other farmers / neighbors have adopted and have been successful	☐
☐	1. High expected profit / return relative to other crops or systems	☐
☐	6. Less water is required	☐

Question E

Most Important (tick one box)	Of the following, which attributes are the Most and Least important to you...	Least important (tick one box)
☐	5. Less labour is required	☐
☐	8. Other farmers / neighbors have adopted and have been successful	☐
☐	9. Government provides subsidies or incentives to plant or change system	☐
☐	2. Stable and consistent price	☐
☐	7. Low initial investment / start-up costs	☐

Question F

Most Important (tick one box)	Of the following, which attributes are the Most and Least important to you...	Least important (tick one box)
☐	6. Less water is required	☐
☐	9. Government provides subsidies or incentives to plant or change system	☐
☐	10. Crop provides cash opportunities when needed (e.g. flexible harvest)	☐
☐	3. Stable and consistent yield (e.g. crop is resistent to weather, pests and disease)	☐
☐	8. Other farmers / neighbors have adopted and have been successful	☐

Question G

Most Important (tick one box)	Of the following, which attributes are the Most and Least important to you...	Least important (tick one box)
☐	7. Low initial investment / start-up costs	☐
☐	10. Crop provides cash opportunities when needed (e.g. flexible harvest)	☐
☐	11. Training and assistance on how to produce or change system is accessible (easy to reach & affordable)	☐
☐	4. Good quality seeds are accessible	☐
☐	9. Government provides subsidies or incentives to plant or change system	☐

Question H

Most Important (tick one box)	Of the following, which attributes are the Most and Least important to you...	Least important (tick one box)
☐	8. Other farmers / neighbors have adopted and have been successful	☐
☐	11. Training and assistance on how to produce or change system is accessible (easy to reach & affordable)	☐
☐	1. High expected profit / return relative to other crops or systems	☐
☐	5. Less labour is required	☐
☐	10. Crop provides cash opportunities when needed (e.g. flexible harvest)	☐

Question I

Most Important (tick one box)	Of the following, which attributes are the Most and Least important to you...	Least important (tick one box)
☐	9. Government provides subsidies or incentives to plant or change system	☐
☐	1. High expected profit / return relative to other crops or systems	☐
☐	2. Stable and consistent price	☐
☐	6. Less water is required	☐
☐	11. Training and assistance on how to produce or change system is accessible (easy to reach & affordable)	☐

Question J

Most Important (tick one box)	Of the following, which attributes are the Most and Least important to you...	Least important (tick one box)
☐	10. Crop provides cash opportunities when needed (e.g. flexible harvest)	☐
☐	2. Stable and consistent price	☐
☐	3. Stable and consistent yield (e.g. crop is resistent to weather, pests and disease)	☐
☐	7. Low initial investment / start-up costs	☐
☐	1. High expected profit / return relative to other crops or systems	☐

Question K

Most Important (tick one box)	Of the following, which attributes are the Most and Least important to you...	Least important (tick one box)
☐	11. Training and assistance on how to produce or change system is accessible (easy to reach & affordable)	☐
☐	3. Stable and consistent yield (e.g. crop is resistent to weather, pests and disease)	☐
☐	4. Good quality seeds are accessible	☐
☐	8. Other farmers / neighbors have adopted and have been successful	☐
☐	2. Stable and consistent price	☐

M1. CASH INCOME ACTIVITIES

Income Activities	Code	Have members of your household been involved in [activity] at ...? 2007 1. Yes 2.No	2012 1. Yes 2.No	If M3=YES, ask questions M4-M7 Who in the household is mainly responsible for this activity? 1. Head 2. Spouse of head 3. Both 4. Other	How many units out of 2012 did members of this household receive income from [activity]? Units (e.g. days, months, harvest, etc)	For each of these units that your hoursehold was involved in [activity], how much gross revenue did you make from this activity? Rp/unit (e.g. Rp/day, Rp/month, Rp/harvest)	how much does your household spend in BUSINESS expenses related to this activity? Rp/unit (e.g. Rp/day, Rp/month, Rp/harvest)	If M2 and M3 are "yes" Has [income source] become less important or more important as a percentage of total income since 2007? 1. More 2. Same 3. Less
	M1	M2	M3	M4	M5	M6	M7	M8
Agricultural w age labor	1000							
Non-agricultural employment w age	1001							
Pension	1002							
Remittances from family members	1003							
Agricultural trading	1004							
Other trading	1005							
Grain milling business	1006							
Food processing business	1007							
Other non agricultural business	1008							
Livestock & animal product sales	1009							
Aquaculture	1010							
Rice production	1011							
Mize production	1012							
Other grains production	1013							
Cassava production	1014							
Sw eet potato production	1015							
Other tubers production	1016							
Red bean production	1017							
Groundnuts production	1018							
Soybeans production	1019							
Mung bean production	1020							
Other beans/pulses production	1021							
Babycorn production	1022							
Broccoli production	1023							

M2. CASH INCOME ACTIVITIES (cont.)

Income Activities	Code	Have members of your household been involved in [activity] at ...? 2007 (1. Yes 2.No)	2012 (1. Yes 2.No)	If M3=YES, ask questions M4-M7: Who in the household is mainly responsible for this activity? 1. Head 2. Spouse of head 3. Both 4. Other	How many units out of 2012 did members of this household receive income from [activity]? Units (e.g. days, months, harvest, etc)	For each of these units that your hoursehold w as involved in [activity], how much gross revenue did you make from this activity? Rp/unit (e.g. Rp/day, Rp/month, Rp/harvest)	how much does your household spend in BUSINESS expenses related to this activity? Rp/unit (e.g. Rp/day, Rp/month, Rp/harvest)	If M2 and M3 are "yes": Has [income source] become less important or more important as a percentage of total income since 2007? 1. More 2. Same 3. Less
	M1	M2	M3	M4	M5	M6	M7	M8
Cabbage production	1024							
Caisin/bok choi production	1025							
Carrot production	1026							
Chili production	1027							
Chinese cabbage production	1028							
Cucumber production	1029							
Eggplant production	1030							
Gherkin production	1031							
Ginger production	1032							
Green bean (buncis) production	1033							
Leek production	1034							
Lettuce production	1035							
Spinach production	1036							
Kangkung production	1037							
Onion production	1038							
Potato production	1039							
Shallot production	1040							
Spring onion production	1041							
String bean production	1042							
Tomato production	1043							
Other vegetable production	1044							
Avocado production	1045							
Banana production	1046							
Mango production	1047							

M3. CASH INCOME ACTIVITIES (cont.)

Income Activities	Code	Have members of your household been involved in [activity] at ...?		If M3=YES, ask questions M4-M7				If M2 and M3 are "yes"
				Who in the household is mainly responsible for this activity?	How many units out of 2012 did members of this household receive income from [activity]?	For each of these units that your hoursehold was involved in [activity], how much gross revenue did you make from this activity?	how much does your household spend in BUSINESS expenses related to this activity?	Has [income source] become less important or more important as a percentage of total income since 2007?
		2007	2012					
		1. Yes 2.No	1. Yes 2.No	1. Head 2. Spouse of head 3. Both 4. Other	Units (e.g. days, months, harvest, etc)	Rp/unit (e.g. Rp/day, Rp/month, Rp/harvest)	Rp/unit (e.g. Rp/day, Rp/month, Rp/harvest)	1. More 2. Same 3. Less
	M1	M2	M3	M4	M5	M6	M7	M8
Mangosteen production	1048							
Melon production	1049							
Papaya production	1050							
Strawberry production	1051							
Watermelon production	1052							
Rambutan production	1053							
Jambu air production	1054							
Star fruit production	1055							
Pineapple production	1056							
Snack Fruit production	1057							
Duku production	1058							
Other fruit production	1059							
Flower production	1060							
Other spices production	1061							
Grass or forage crops production	1062							
Tea production	1063							
Coconut production	1064							
Sugarcane production	1065							
Tobacco production	1066							
Other annual crops production	1067							
Other perrenial crops production	1068							
Other assistance program	1069							
Other income source (1)	1070							
Other income source (2)	1071							

N. PERCEPTION OF CHANGE

N1	N2 How w ould you rate each of the follow ing: 1. Good 2. Fair 3. Poor 4. DK / NA	N3 Compare to 2007, Do you think each of the follow ing: 1. Improved 2. No change 3. Worse 4. DK / NA
1 availability of cereal seed		
2 availability of horticulture seed		
3 quality of cereal seed		
4 quality of horticulture seed		
5 availability of subsidized fertilizer:Urea, SP-36, ZA, NPK		
6 availability of other fertilizer		
7 timing of fertilizer availability		
8 price of subsidized fertilizer in accordance to the highest retail price (HET)		
9 price of other fertilizer		
10 availability of credit		
11 availability of extension services		
12 availability of marketing information		
13 availability of w eather information		
14 number of buyers for crops		
15 roads in your district		

What type of services w ould help your household the most in improving agricultural productivity and raising income?
1. Very important
2. Important
3. Less important
4. DK/NA

N4	N5
1 information to raise yields of my crops	
2 information on how to grow new crops	
3 information about prices and markets	
4 information about w eather	
5 less expensive seed	
6 less expensive fertilizer	
7 less expensive agricultural credit	
8 new irrigation schemes	
9 repair of existing irrigation schemes	
10 better maintenance of existing roads	
11 construction of new roads	
12 construction of w arehouses	

N6	N7 How has [..] changed since see code	N8 [If change] What is the main rason that you change [...]? see code
1 The area you plant to rice		
2 The yield of your rice		
3 The area you plant to horticulture		
4 The yield of your horticulture		

Code for N7
1. Increased
2. No change, >> next row
3. Decreased
4. Not relevant e.g. new crop, >> next row

Code for N8 (reasons)
1 Change in price of the crop(s)
2 Change in the price of inputs
3 Change in ability to pay for inputs
4 Change in availability of credit
5 Change in services offered by buyer
6 Change in know ledge of grow ing crop
7 Change in rainfall patterns
8 Change in quantity of inputs used
9 Change in amount of farm land
10 Change in amount of irrigated farm land
11 Change in ow nership of ag equipment
12 Change in soil fertility
13 Other

How has the w ell-being of your household changed since 2007? [ ] N9
1. Much better
2. Somew hat better
3. Not much different (>> finish)
4. Somew hat w orse
5. Much w orse
6. No opinion or NA (>> finish)

[If change in w ell-being] What are the main reasons for the change in w ell-being of your household?

	1. Yes 2. No	
Change in crop prices		N10
Change in crop yields		N11
Change in crops grow n		N12
Grow ing horticulture crops		N13
Change in livestock income		N14
Change in non-farm income		N15
Change in health of family members		N16
Change in level of crime in area		N17
Other		N18