Doctoral Thesis

Impact Evaluation of Agricultural Training upon Information Diffusion and Technology Adoption: Evidence from a Randomized Field Experiment in Indonesia

（農業研修が情報の伝播と技術の普及にもたらす影響評価：
インドネシアにおけるランダム実験をケースとして）

東京大学院新領域創成科学研究科

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アユ　プラティウィ

DISSERTATION

IMPACT EVALUATION OF AGRICULTURAL TRAINING UPON INFORMATION DIFFUSION AND TECHNOLOGY ADOPTION: EVIDENCE FROM A RANDOMIZED FIELD EXPERIMENT IN INDONESIA

Thesis submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy in International Studies in Graduate School of Frontier Sciences, the University of Tokyo, May 2016

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ABSTRACT

"Impact Evaluation of Agricultural Training upon Information Diffusion and Technology Adoption: Evidence from a Randomized Field Experiment in Indonesia"

Technology has long been seen as a major contributor to economic development, but permeating technology in the developing nations has been a continuous challenge. Majority of livelihood in the developing nations depend on agriculture and live in the rural area. Formal educational institutions are deemed lacking to push technology to the end user, and informal institutions can offset this lack in the rural area where majority of the people live. In this dissertation, I explore three different set-ups using empirical framework to better understand how technology diffuses and adopted in the rural area by carrying out a randomized field experiment of institutionalized agricultural training in Indonesia. Building on a 3-years panel dataset, I examine how the interplay between formal extension services and informal rural social network can better explain the technology transfer and adoption in the rural area.

Agricultural information are transferred through social interactions, so ties to agricultural informants and network structures within farmers' local neighborhood determine farmers' ability for information gathering mechanism. The role of various network ties is examined, including friendship network and advice network, upon farmers' knowledge gathering ability during formal training. Although the numbers of ties are important for knowledge gathering process, they do not necessarily result in better quality of information acquired, as friendship network in fact hurts productivity. Further examination explores how farmers' position in their local network structures influences their information processing skill. Farmers who occupy a central position in their network structures in their local neighborhood are found to perform better in learning outcomes, indicating that one's position in their local network determines their ability in facilitating problem-solving activities in an unknown environment outside their locale.

Agricultural training in general helps disseminate agricultural technology but training carried out in most remote place is found to drive adoption due to significantly strengthened social network. Training is administered in varying locations (in farmers' hometown and in remote locations comprise intra-island and inter-island locations) to investigate the effect of both locations and social learning on agricultural technology diffusion and adoption. Identical training content is given regardless of location. Training, regardless of location, is found to improve farmers' knowledge regarding agricultural technology, but only training held in an inter-island location significantly spurs the adoption of water-conservation techniques. Farmers trained in an inter-island location tend to communicate more frequently with their peers and experts upon returning from training, which induces their propensity to adopt the technology.

Institutionalized agricultural training also has a profound impact in stabilizing farm income of training participants who belong to below-median farm-income category. Agroforestry has long been regarded as a means for income smoothing for poorer household. After the training, training participants in general reduce plant diversification as they may find it inconsistent with their farm management strategy. However, relative to the non-poor, poorer farmers tend to diversify more or keep their number of crops. Training participants in general are also well-informed regarding the economic and environmental benefits of agroforestry, with poorer farmers being more aware on its economic merits and richer farmers being more informed on its environmental benefits. Upon returning from the training, the poor is also found to increase the depth and size of social network with their agricultural informants. Impact evaluation assessments also show that crop diversification is negatively associated with income vulnerabilities, indicating the program's relevance for poverty eradication strategy.

Overall, this dissertation found that formal institutions, in the form of institutionalized training, and informal institutions in the form of rural social network equally complement and play important role for technology advancement in the rural area. Training serves as an effective measure to disseminate agricultural information, and rural social network helps to push technology adoption due to the increased social learning effects. Future agricultural training should put more emphasis on knowledge facilitation which enabling information diffusion process amongst participants and consider the potential spillover to non-training participants upon the completion of the training. Future agricultural extension policy should extend the approach to consider the interplay between formal institutions such as extension systems and informal institutions such as rural social network for better development outcomes.

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DISSERTATION OVERVIEW

1.1 BACKGROUND

Technology has long been seen as a major contributor to economic development. At the macro level, some influential studies have drawn models showing that the indefinite investment in human capital had spillover effect on driving growth and productivity (Romer, 1986, 1989). Lall (2000) postulated that economic development is as an evolutionary process with technological learning at its core, citing standard neoclassical economics as inadequate in explaining the theory of the key processes and institutions involved in the progress of development. Departing from this theory, Nelson (2008) argues that long-run economic change involves the co-evolution of knowledge and technologies in use and the institutional structures supporting and regulating these. The basic challenge in the process of development for a region is to learn new ways of achieving things. In this context, developing countries have lagged not just economically and socially, but also technologically. Efforts to facilitate technology penetration into developing countries are likely to help bridge the information barrier between developed and developing regions. However, compare to those of developed nations, pushing new technologies in developing nations is far more challenging and complex. Formal educational institutions in the developing nations are faced by challenges of huge demand but less supply to respond to the needs of the people. Informal institutions, on the other hand, can offset the areas in which the formal educations are lacking, especially in the rural area where majority of the people live.

As majority of livelihood in developing countries belong to agriculture sectors and live in the rural area, technological inclusion for rural people plays important role to enhance their capability to evaluate new knowledge, assimilate it, and put it into their ends (known as absorptive capacity). Absorptive capacity is largely a function of prior related knowledge of economic agents or system (Cohen and Levinthal, 1990). Improving their absorptive capacity may thereby increase their ability to participate in more economic activities. Technology allows rural people to get more access to knowledge and resources and that will help them to gain more economic benefits. Eventually technology can facilitate the acceleration of farmer education, develop agricultural labor skills, and continuously enhance the learning process for all farmers, thus increasing their earnings and professional capacities.

Improving agricultural productivity and quality requires a functioning mechanism of technology generation and transfer, as well as a means to implement these technologies. Various agricultural information and knowledge in the developing nations are mostly transmitted through extension service –that is an institutionalized top-down approach led by the government, usually the ministry of agriculture, to advance technology usage thus increasing productivity. Extension services serve as the proper institutional system to deliver these information pertains to agriculture to farmers. Extension services provide farmers with access to relevant advice and appropriate incentives to adopt and continuously use new technologies given that they suit farmers' socio-economic and agronomic situations. Evaluating the impacts of extension involves measuring the relations between extensions and farmers' knowledge, adoption of better practices, and use of inputs; farm productivity and profitability; and related improvements in farmers' welfare (Anderson and Feder, 2004).

Farmers may get information from various sources including public and private institutions, but extension is found to have greater impact on its early stages of dissemination of a new technology. Eventually as more farmers become aware of new technology, the impact of extension diminishes (Byerlee, 1998). From this stage onwards, informal institutions consisting of various agrarian actors play important roles to push technology adoption for non-adopters, amongst them are neighbors and peers through social interactions.

Informal interpersonal networks play a critical role in the knowledge-transfer process; and social learning amongst relatives and neighbors served as an important tool to facilitate knowledge dissemination in the rural area (Conley and Udry, 2010; Munshi, 2004). Diffusion is more likely to occur in close proximity rather than places farther away from each other (Backstrom et al., 2010). However, in the dense networks within close proximities such as those in rural areas, people tend to share common characteristics in social background, such as similar beliefs, values and education (Monroe et al., 2014). There is not much new information circulating amongst people coming from similar social backgrounds. In order to bring advancements to societies with dense networks, agents of knowledge-diffusion are required. To hasten the diffusion processes amongst the community members, agents should come from the community. Training or other form of knowledge promotion is required to elevate the technology level for the people coming from dense network community.

This dissertation aims to explore the combination of effects on how agricultural training and the interplay of the role of both extension services (as formal institutions), and neighbors and peers (as informal institutions) can help explaining the mechanism of technology diffusion and adoption in the rural area.

1.2 OBJECTIVE

This dissertation responds to the need to understand the mechanism of agricultural technology diffusion and adoption in the rural area, using a randomized experimental method. I combine approaches of agricultural extension and social network analysis, and particularly look at the impact of a social experiment of exposing farmers to institutionalized training on agricultural technology diffusion and adoption. I am interested to look at how different exposure in different training environment can influence farmers' social network which will eventually result in attitude changes in their current agricultural practices. I argue that while training content is an utmost important in educating farmers' on better farming practices, learning environment during the training as well as social interactions are also equally important on pushing motivation and enthusiasm to enable them to adopt better agricultural techniques.

To serve the purpose, I experiment with the recreational activities embedded in the different training locations as a stimulus for motivating the farmers upon returning from the training. I carried out agricultural training in three different locations, namely in their hometown, in the same province but different district (intra-island), and in the neighboring and more-developed island (inter-island) to gauge the network effects, which will eventually influence farmers to obtain new knowledge and implement better agricultural practices in their farmland.

Current literatures on agricultural technology diffusion and adoption are replete with theories that try to explain why people adopt technology or not, how technological innovations diffuse in a social system, and factors that facilitate or impede their implementation. These theories and models range from general forms to more specific ones.

In addition, numerous research studies have also been conducted empirically that have drawn from such theories as bases. This dissertation adds three methodological contributions to the existing literature as followed:

First, training participation is randomized to allow rigorous analysis on the training impacts. There are not many existing literatures which provide proper randomization on study pertains to agricultural training, as mostly were done through voluntary participations, in addition to the absence of panel data in consistent time period. I conduct a randomized controlled trial and post-evaluation study that spans across three years of research period. This dissertation serves as an extension of social experiment study of agricultural extension.

Second, I administer the training in varying locations to see how both learning and network effects differ across locations. To my knowledge, this is the first that this study is ever conducted using both social network analysis and econometrics approach. Other similar studies with recreational activities embedded into the training program do not use a randomized experiment approach to support the findings but instead exploratory and qualitative studies.

Third, this study also offers insights on how benefits of certain agricultural practices are perceived across different income groups and how they can reduce income vulnerabilities. While many studies have found positive associations between technology adoption and farm productivity, poverty reduction is rarely examined as it was assumed to follow. This dissertation shows that technology can improve productivity and reduce income vulnerability within medium-term post training, particularly for lower-income farmers.

1.3 MOTIVATION OF THE DISSERTATION

Impact assessment of formal extension services cite its weaknesses on accountability, being cost-intensive, as well as difficulty in attributing its impact on farmers' farm advancement such as welfare and income smoothing. Moreover, in most government's intervention program, selected target farmers are not the representative of the whole agrarian community, making impact evaluation studies difficult to measure in the whole population-level. Current critics to formal extension services calls for the urge to estimate the effects of formal extension using quasi-experimental approach; to carefully identify and isolate the impacts altogether with its consequences on farmers' livelihood.

Informal institutions, in the form of social learning with neighbors and peers can complement and balance the inadequacy of formal extensions services. Farmers who lack the means of accessing formal extension services can rely on their social networks within their neighborhood and obtain new knowledge and advances regarding farming practices from their agricultural informants within their village vicinity. However, these approaches too, are difficult to estimate quantitatively, as measuring informal networks require further examination on farmers' communication patterns, their structural position in their neighborhood, as well as individual characteristics. Presently, most studies are carried out in qualitative manners hence are difficult to precisely estimate its impact. Informal networks, are also heavily influenced by many random effects, resulting in the need to employ panel analysis to capture its effects.

This dissertation attempts to fill the current gap in the existing literatures of both formal and informal institutions in pushing agricultural knowledge dissemination and adoption. In this research, I incorporate both approaches of formal and informal institutions in advancing farmers' rural innovation system and welfare, in one body of research. To serve the purpose, I carried out formal agricultural training for the randomly selected farmers, and examine how it affects information transmission and technology adoption in the rural area. At the same time, I also evaluate further the role of informal networks in supporting information disseminations within the network.

The differentiations with the current literatures are threefold:

1. Training participation is randomized to allow for a rigorous analyses of training impacts.

Contrary to the existing social interventions that tend to select particular contact farmers to undertake training programs, this research selects the participants by randomization to take accounts the representation of the whole farming population. This approach enables the impact assessment to be measured quantitatively in consideration of the persisting random effects that could simultaneously affect the diffusion and adoption of agricultural technology.

2. Institutionalized formal training is carried out to examine the effects of formal extension on farmers' agricultural advancement

Variation of the extension services coverages across community and village exists. As extension officials hold dual position as civil servant and agricultural informant at the same time, variation in the dissemination of information may be present in the rural area. Some extension officials may be able to juggle both roles equally while some others may not, especially when accountability of such tasks are rarely reported in periodical basis. Considering these facts, agricultural training is deemed suitable to be undertaken for farmers, particularly when no farmers in the district have never been exposed to institutionalized training.

3. Various informal network is examined as a proxy for informal institutions in helping the diffusion and adoption of agricultural technology

In many researches, informal network is found to be the catalyst of information diffusion and adoption, and serves to complement the role of formal institutions in the rural area. However, such roles in its entirety (including communication patterns and network's structural position) are rarely examined in tandem with the role of formal institutions. This research takes the network aspects into different levels by incorporating the panel analysis in various social learning context to examine its importance in complementing formal institutions.

This whole dissertation chapters hypothesize that at the beginning, formal institutions in the form of agricultural training is important to enhance farmers' ex-ante knowledge regarding agricultural practices. However, for a technology to be fully practised in their farmland, farmers need encouragement from many parties, who, amongst them, are their informal rural network. Even though knowledge is a pre-requisite for adoption, adoption takes an entirely different measure to be fully embraced, which is where the informal network takes function.

1.4 CHAPTERS OUTLINE

This dissertation consists of eight chapters in overall. Chapter 1– Dissertation Overview, contains introduction to the work – and Chapter 2 – Literature Review outlines past studies and literature review revolving around the mixed impact of extension service, which consists of both agricultural training and extension.

The main body of the dissertation comes in Chapter 3 to Chapter 6 with the following details: Chapter 3– Study Context, Social Experiment, and Data Collection, Chapter 4– Effects of Network on Knowledge Acquisition: Lessons from Agricultural Training in Rural Indonesia, Chapter 5– Effects of Varying Training Locations on Agricultural Technology Diffusion, Adoption, and Social Network, and Chapter 6– Reducing Agricultural Income Vulnerabilities through Agroforestry Training: Experience from Poorer Households.

In Chapter 3, I outline the details of the study area and social experiments. In Chapter 4, I examine farmers' various social network and their network position within their local community and see their effects upon knowledge-acquisition process during agricultural training. In Chapter 5, I provide the evidence of the role of institutionalized training in strengthening farmers' network, which is eventually propelling farmers' technology adoption. In Chapter 6, I examine the effectiveness of institutionalized agricultural training in promoting agroforestry to reduce income vulnerabilities. Here I distinguished between poorer and higher income farmers to see agroforestry system's relevance to the poor, their ability to adopt, and the ultimate economic outcomes of adoption.

Finally the last part concludes with Chapter 7 which consists of summary of findings, limitation of this study, and policy recommendations.

2

LITERATURE REVIEW

This dissertation combines literatures of formal and informal agricultural sources of information, namely agricultural extension services and rural social network; as well as reviews past studies regarding technology adoption, to help build foundations for the three main arguments in Chapter IV to VI. This chapter explores important literatures capturing both theoretical and empirical platforms of extension, network, and technology adoption.

2.1 FORMAL SOURCES: AGRICULTURAL EXTENSION.

2.1.1 *Technology Adoption in the Context of Developing Countries*

Developing countries are characterized by high birth rates, poverty, and relatively high reliance on more-developed countries (Perkins, 2003). Education has been seen as the best way to solve these problems, as investment in human capital has been associated with economic growth (Nelson and Phelps, 1966; Benhabib and Spiegel, 2005). Developing nations are struggling to get their people out of poverty, but at the same time, these countries are facing immense problems in areas of education and training (Arias and Clark, 2004). The challenge of income vulnerabilities, as well as population growth which aggravate resources scarcity; has made the world placing a lot of pressure on training and educational demands altogether with infrastructures in the developing countries. Promoting economic development has always been seen in conjunction with increasing access to knowledge base at the technological frontier, but bridging the technological divide has been an uphill task[1].

Technology has been viewed as an agent of change in developed as well as developing countries. Early works regarding agricultural adoption in developing countries are pioneered by Griliches (1960) who studied the diffusion of hybrid corn in the United States using econometrics modeling. The theoretical and empirical works that are proliferated assumed that farmers behave as profit maximizers and considered the heterogeneity of attributes resource endowments among individual as the key determinants of diffusion patterns because of its effects on the utility of adoption for individuals (Feder et al., 1985; Sunding and Zilberman, 2001).

Agriculture production success is not only linked to the proper agricultural system and technological innovations, but also the right uses of agricultural information which will greatly help to boost the agricultural production. Presently, agricultural technology permeation in the developing countries expands its focus to address the sustainability issues in addition to improving productivity and welfare. The Food and Agriculture Organization (FAO) of the United Nations formulates five attributes of sustainable agriculture (SA), namely: to have features of resource conserving (of land, water, plant, and genetic resources), environmentally non-degrading, technically appropriate, and economically

1 Science, technology and innovation for sustainable development in the global partnership for development beyond 2015 http://www.un.org/en/development/desa/policy/untaskteam_undf/thinkpieces/28_thinkpiece_science.pdf last accessed 2015/12/18

and socially acceptable (Lee, 2005). To meet these objectives, technology promotion in the developing countries should also consider the environmental effects in the longer term, while at the same time also put utmost emphasis on the welfare and productivity of the people on a continuous basis.

2.1.2 *Overview of Extension Service*

Improving the quality of life of the farmers in the developing countries has been an important issue faced by extensive stakeholders ranging from the local government, NGOs, researchers and the farmers themselves. To acquire better farming practices which will eventually lead into shared prosperity, major advances in agricultural technologies have to be effectively disseminated to the farmers (Isaac, 2007). Technology helps rural people to obtain more access to knowledge and resources that will lead to more economic benefits. Successful knowledge that can be translated from laboratory to farmland can improve farm efficiency and productivity; transforming the farm practices into a more productive one. However, knowledge dissemination has largely become a huge challenge, as communicating advancement to primarily low-educated farmers is problematic in nature.

Several studies have particularly highlight the means of knowledge dissemination to the farmers in developing countries, especially notable is through extension system (Hussain et al., 1994; Ejembi et al., 2006). According to Anderson (2007), agricultural extension and advisory services are defined as "the entire set of organizations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills and technologies to improve their livelihoods". Agricultural extension serves as a means to facilitate knowledge transfer, from global knowledge base and from local research center to farmers, enabling farmers to clarify their own goals and possibilities and educating them various ways to make better decisions and stimulating desirable agricultural development (van den Ban and Hawkins, 1996). Extension service plays pivotal role to improve rural human capital that can eventually culminate in the improvement of rural welfare (Feder et al., 1985; Roberts, 1989; Jarrett, 1985).

In developing countries where more than 90% of the world's nearly 1 million extension personnel are located (Bahal, 2004; Anderson and Feder, 2004) the importance of investment in extension services to improve farm productivity and increase farmers' welfare has been deemed very crucial. A recent meta-analysis of 289 studies of economic returns to agricultural research and extension found that the social rate of return to investments in agricultural R&D has been generally high (Alston, 2010), while mixed results have been reported by Evenson (1997) meta-analysis of 57 studies, that impacts vary widely. In African countries, extension systems are regarded as failing and outdated (Malawi and Services, 2000; Eicher, 2001). A more pessimistic view comes from Rivera et al. (2002) who cited extension systems as "failing" and "barely functioning at all" especially in low-income developing countries.

2.1.3 *Approaches in Extension*

Recently, newer approaches on agricultural extension were introduced. These new models reflect efforts to offset the weaknesses that the traditional extension possesses. Improvements such as the frequency of visits, span of controls, amount of information disseminated, as well as farmers' bottom-up participations have been incorporated. These new approaches are:

1. Training and Visit Extension

The Training and Visit (T&V) extension was initially started in 1975 in more than 70 countries by the World Bank (Umali-Deininger and Schwartz, 1994). The system involves many levels of field staffs, with a single line of command. Specialists were employed to train field-staffs and to act as troubleshooters for reports by the field staffs. The system places the importance to assure technical knowledge dissemination by conducting a periodical visit to the village in every two weeks cycle. A selected "contact farmer" is assigned to act as the main contact person for information dissemination in the village. This "contact farmer" will then help to spread the new knowledge to their neighborhood. Extension personnel are also exposed to many mandatory training and extra remuneration to do monitoring and evaluation in the village.

While the system is seen as an improved version of the traditional extension, it has created weaknesses in terms of cost, monitoring, and accountability. The system possesses heavy reliance to the selected "contact farmers", so when these "contact farmers" are unavailable and they are often replaced by other farmers, information diffusion becomes problematic due to unidentifiable contact farmers. Furthermore, the biweekly visit schedule is deemed too intense, as farmers begin to lose interest by frequent checks and extension workers have less and less information to pass on to the farmers. Aside from the results accountability that remained unmonitored, the method is also considered very costly due to the smaller farmers to extension workers ratio that requires mobilization of numerous extension personnel (Feder and Slade, 1993; Antholt, 1994).

Feder and Slade (1993) mention positive implications of T&V extension in India on yield, 3 years after the project begun. However, studies in Pakistan (Hussain et al., 1994) and Kenya (Gautam, 2000) report no significant effects in the longer time period.

2. Farmer Field School

Farmer Field School (FFS) is initially started as a program to teach farmers regarding integrated pest management in Indonesia (Feder et al., 2004) and Vietnam (Pincus, 1999; van de Fliert et al., 2007), but has been introduced in 78 countries ever since (Van den Berg and Jiggins, 2007). The FFS method uses the participatory approach to encourage farmers' own experimentation and problem solving. FFS typically educates farmers in terms of agro-ecosystem analysis using both technical and practical approaches to farming. FFS lasts in one to two seasons, and enables farmers to graduate with a new skill. During the school term, field school participants are expected to be "self-teaching experimenters, and effective trainers of farmers and extension workers" (Wiebers, 1993). The program usually spans in 9 to 12 half-day sessions of hands-on farmer experimentation and informal training to a group of 20 to 25 farmers during a single crop-growing season. FFS was initially led by paid trainers in village-level. Farmers learn from each other through group interactions, enabling them to hone their skills on decision-making, as well as leadership and management skill (Fliert, 1993). Selected participating farmers are chosen to receive additional training that qualifies them as farmer trainers, with official backup support, such as training materials.

A meta-analysis of FFS is done by van den Berg (2004) who explored a synthesis of 25 evaluation studies on FFS focusing on integrated pest management. The study reported that although considerable reductions in pesticide use and increase in yields are found, the methodologies of these studies vary, indicating the complexity of estimating the impact of such interventions. These studies reviewed were either having limited scope albeit with statistical rigor or comprehensive but limited coverage.

Even though evidence on the impact related to pesticide reduction, increases in productivity, and knowledge gain among farmers (Praneetvatakul and Waibel, 2003; Rola et al., 2002) and empowerment (Züger Cáceres, 2004) are found, some studies confirmed that FFS have limited or no effect on economic performance, the environment and health and farmer-to-farmer dissemination of information and technologies (Feder et al., 2004; Quizon et al., 2001). The diffusion effect of FFSs is also debatable with several studies showing little diffusion of knowledge from FFS to non-FFS participants (Rola et al., 2002). The causes of these are presumably because the training content is difficult to transmit in casual and non-structured communications. The challenge with FFS is the financial sustainability as the intense training program is expensive per farmers trained. Cost issue can be mitigated if farmer trainers were to become the main trainers with significant community funding and if informal farmer-to-farmer communication were used to facilitate knowledge diffusion. These mixed reviews highlight the need to rethink about both the curriculum and training approach.

2.2 INFORMAL SOURCES: RURAL SOCIAL NETWORK

Although formal sources of information have been introduced to guide and advise farmers regarding pertinent farming practices, previous studies have confirmed that little of this information reaches the desired recipients, and selected target farmers are not representative of the whole agrarian community (Boahene et al., 1999). Feder et al. (2001) raise critics on how current extension services are being managed, notably highlighting the difficulty of attributing the impact of extension on farm productivity, its weak accountability, political commitment and support, as well as fiscal sustainability issues. Extension services usually employ large number of local government officials at the district or rural level, and their duties are often overlapped with many other public servant functions such as paperwork and collecting statistics instead of assigning more time for advising farmers (Feder and Slade, 1993; Purcell and Anderson, 1997).

In addition, Feder et al. (2001) argued that many factors may possibly affect the performance of agriculture hence it is difficult to attribute specific impacts at the farm level to extension services. Impact of extension should be measured extensively, taking account the relations between extension and farmers' individual characteristics, knowledge, adoption of technology, the use of inputs, as well as productivity and improvement in farmers' socio-economic aspects. What makes things even more complicated is that farmers' decision is influenced by many other systematic and random effects, such as (prices, credit constraints, weather, other sources of information), hence, measuring the impact of extension services require careful use of econometric and quasi-experimental approach.

Information and knowledge are the prerequisites of technology adoption in the rural area; therefore, information dissemination is an important feature to propel adoption. To balance this lack of information from formal sources, other types of informal sources of information are created and exist within farming communities (Mortimore and Adams, 2001; Campbell, 2005). Farmers who have limitations to access information from formal sources can obtain knowledge within their social network (Boahene et al., 1999; Lyon, 2003). The study on information spread across social groups overtime, called the "diffusion of innovations", is one of the most-studied phenomena and ranged across disciplines, from geography and sociology to economics (Mahajan and Peterson, 1985).

Rogers (2003) defines diffusion as the process by which an innovation is communicated through certain channels overtime amongst members of a social system. Granovetter (1973) posits that information relating to new knowledge is embedded in these social network and may only be apparent in the context of interactions and relationships. Farmers' social learning regarding agricultural practices rely heavily on social relationships in the larger farming community and informal network structures (Foster and Rosenzweig, 1995; Conley and Udry, 2001; Davidson-Hunt, 2006; Kiptot et al., 2006; Monge et al., 2008). These information flows transmitted amongst individual are strongly related to their social environment, the network of their contacts, and their status within that network (Feder and Savastano, 2006).

To date, only few researches addresses the structure of farmers' communication patters, especially in advice network structure, to identify the role of structural positions and the consequences (see Isaac, 2007, for the case of cocoa agroforestry system in Ghana). Studies pertain to informal learning amongst farmers are mostly explained in non-econometrical methods, as sociological, anthropological, or educational aspects of learning are difficult to capture in quantitative manners. While the availability of panel data and the employment of quasi-experimental approach are important to establish causality and isolate the effects, such studies are currently lacking in the existing literatures.

2.2.1 *Social Learning*

Studies of diffusion of innovations that particularly focus on social learning started to gain attention after Ryan and Gross (1943) published an economics study about farmers' communication patterns that result in the switch of hybrid-corn seeds in the United States. Early works that focus on identifying key factors regarding adoption decision, put emphasis on sociopsychological factors determining individual adoption, such as personality, education, and economic status (Hildebrand and Partenheimer, 1958), the effects of farmers' perception regarding the attributes of innovations on adoption (Fliegel and Kivlin, 1966), and other significant factors such as belonging to certain neighborhood, given the social influence exerted by group values and norms (van den Ban and Willem, 1960; Flinn, 1970).

Insights and findings obtained from these early studies converged in the late 1960s with advances in diffusion studies conducted by (1) communication scholars, who stressed the role of a social interaction in shaping the process (Czepiel, 1974), and (2) medical sociology experts who recognized social cohesion as a key determinant of the diffusion of new prescription drugs among physicians (Menzel and Katz, 1955; Coleman et al., 1957). As a result, studies on diffusion of innovations advanced toward a relational perspective that emphasizes the effects of sociostructural factors, explaining diffusion not only on the basis of individual attributes but also according to the relationships among various actors involved in the process (Lionberger and Copus, 1972).

2.2.2 *Homophily and Heterophily*

Rogers Everett (1995) utilizes the terms homophily and heterophily to help explain the information transfer from one individual to another. Homophily is "the degree to which two or more individuals who interact are similar in certain attributes, such as beliefs, education, social status, and the likes". The interpersonal channels of any diffusion process are intertwined to the social system through which an innovation diffuses. People who belong the same groups such as in age, occupation, education, social-class, religion, race and ethnicity, and share similar interests are said to be homophilous (McPherson et al., 2001). When individuals share the same set of beliefs and are similar in some respects, they are more likely to form positive attitudes towards each other hence adopting a new idea more easily (Rogers, 2003). He also postulates that innovation diffusions mostly involve other individuals that are heterophilous. Innovations largely spread from an area of high concentration (i.e. agents of change) to that of low concentration (i.e. clients); unfortunately, these two different actors may come from different background or beliefs, making communication difficult to make. Even if they talk the same language and communication can be initiated, social barriers may exist that prevent them to intensely interact. Unfortunately, differences in aspects such as education, occupation, and social status are common indication of heterophily.

Departing from this premise, several studies to explore how different structural characteristics of social networks affect natural resource management. Homophilous network has the potential to hinder innovation by 1) cutting off actors from needed information, and 2) imposing social norms that discourage innovation. Heterophilous network allows actors to access outside information and overcome social norms with support from outside the local network, in addition to increasing access to diverse forms of other capital. Because heterophily brings in new and potentially novel information; homophily provides the group resilience needed to absorb the benefits of heterophily; the two capitals are complementary. Mathijs (2003) shows that farmers who are more open to both professional and non-professional contacts, are more likely to adopt government's promoted agricultural-environment scheme. When the degree of homophily is high, especially in the rural area (particularly the village-level) where people belong to the same socio-economic characteristics live together, there is a need to expose them to new agents of change in order to bring innovations in the locale.

2.2.3 *Factors Affecting the Decision to Adopt Technologies*

The decision to adopt a new technology at one point of time is not merely about the choice of adopting versus non-adopting, but also adopting now or deferring the decision until later (Hall and Khan, 2003). It is important to look at the choices on this way due to the basis of cost-benefit. Cost variables are related to monetary and non-monetary expenses. The benefits from adopting a technology can be received throughout the life of the acquired innovation, while the costs, especially those of the non-monetary "learning" type, are typically incurred at the time of adoption and cannot be recovered. When using a technology, some on-going fees may be incurred; but they are typically less than the full initial cost. Therefore, before adopting a technology, a potential adopter may weigh the fixed costs of adoption against the benefits he expects; but after adopting, these fixed costs are irrelevant because a great provision of them cannot be recovered and have already been considered as sunk cost. According to (Hall and Khan, 2003), these imply two things:

First, adoption, by nature, is usually a state that once entered, cannot be left. There are rarely any new technologies being abandoned in favor of an old one. This is because the decision to adopt faces a large benefit minus cost hurdle; and once this hurdle is passed, the costs are sunk and the decision to abandon requires giving up the benefit without regaining the cost.

Second, under uncertainty about the benefits of the new technology, there is an option value to waiting before sinking the costs of adoption, which may tend to delay adoption. Wejnert (2002) has provided a conceptual framework to better understand variables that appear to modulate the adoption of technology, namely the six actors of innovation. These are: societal entity of innovators, familiarity with the innovation, status characteristics, socio-economic characteristics, relative position in social network and personal characteristics that are associated with cultural variables that modify personality characteristics of actors at population level.

Existing literatures have largely incorporated Wejnert (2002)'s approaches in explaining technology adoption, namely societal entity of innovators, status, socio-economic, and personal characteristics, as well as familiarity with the innovations. However, there is not much study that examines how the relative position in social network may possibly affect the process of diffusion and eventually the adoption of technology. This dissertation tries to provide better understanding of technology diffusion and adoption process that incorporates such effect. It also attempts to enrich the existing literatures by examining the rest of the factors as mentioned by Wejnert (2002).

3 METHODOLOGY AND CASE STUDY AREA

3.1 STUDY CONTEXT: INDONESIA.

Most of the economically marginalized people lives in rural area and depends on agriculture and forestry. In 1999, 76% of Indonesians living below the poverty line live in rural areas (Pradhan et al., 2000). Despite the declining share in GDP, agriculture still provides income for majority of Indonesian (in 2012, 49 million employment or 41% of the total labor force[1]. Indonesia benefits from an ideal geographical location for agriculture, which supports both coffee and cocoa plantations. In 2013, Indonesia has 1.3[2] and 1.6[3] million hectares for coffee and cocoa plantations respectively and more than 90 percent of these plantations are cultivated by small-scale producers (Thurston et al., 2013). These commodities have been two of Indonesia's most important export commodities (Kaplinsky, 2004), as the country holds the reputation as the fourth biggest coffee producer[4] and the third largest cocoa exporter[5] in the world.

Of its coffee exports, 75% is Robusta beans and the rest is Arabica[6]. Coffee-growing in Indonesia began during its colonial period and has since played an important part in the country's growth. Cocoa is presently drawing increased interest from local farmers because both local and international demand for cocoa products greatly exceeds the country's current supply capacity and world prices have been constantly favorable. The cocoa sector has therefore seen massive growth in recent years, driven especially by a rapid expansion of smallholder farmers cultivating cocoa. For these two commodities, Indonesian smallholders contribute by far most of the national production, thus overpowering big state plantations and large private estates (Dietsch et al., 2004; Neilson, 2008).

Nevertheless, the country is currently facing challenges in boosting the economic contributions of these two crops. Even though the country's geography and micro-climates are all well-suited for the growth and production of coffee and cocoa, environmental degradation due to harmful agricultural practices is apparent. The majority of Indonesia's coffee and cocoa output is produced by smallholders who lack the financial means to optimize their production capacity, resulting in declining production due to aging trees, diseases, floods, and so on. In recent years the government has undertaken ambitious reforms intended to revitalize coffee and cocoa plantations in Indonesia as well as to increase capacity building among smallholder farmers. Lampung Province, as one of the largest coffee and cocoa producing area in the country, has been facing problems such as aging plantations and traditional farming systems. Since 2009, Ministry of Agriculture

1 http://www.indonesia-investments.com/culture/economy/general-economic-outline/agriculture/item378 accessed 2015/09/15
2 http://www.reuters.com/article/2013/07/31/indonesia-coffee-output-idUSL4N0G12W520130731 accessed 2015/09/15
3 http://www.reuters.com/article/2012/03/14/us-food-summit-indonesia-cocoa-idUSBRE82D0TF20120314 accessed 2015/09/15
4 Statistics compiled by International Coffee Organization, http://www.ico.org/prices/po-production.pdf retrieved May 23, 2015
5 Statistics compiled by UN Food and Agriculture Organization
6 http://www.indonesia-investments.com/business/commodities/coffee/item186 retrieved April 20, 2015

has carried out national program to increase farmers' productivity and product quality by reactivating the extension system in the commodity-producing districts in the forms of farmers group (Hasibuan et al., 2012). Agricultural extension system across Indonesia is officially regulated for all types of products under the Law 16/2006 on Extension System for Agricultural, Fishery and Forestry (Neilson, 2008). Farmers cultivating the same commodity and coming from the same or nearby neighborhood is encouraged to form a farmers group, which usually comprises 20 to 30 people. Farmers group may not necessarily represent everyone in a village. One or two extension workers are assigned to each group and monitor the farmers' progress and advances at least once a month through monthly group meetings. Government's subsidies for new varieties, fertilizers and even new agricultural knowledge are often disseminated through farmers group under the supervision of the district-government officials. This system of extension, despite being a top-down approach from the government, is typically effective in disseminating agriculture information among group members, as this format enables the "social learning" process to be facilitated naturally.

Lampung Province (Figure 1), the study field site, is subdivided into twelve districts and two autonomous cities. The province's major crops include Robusta coffee beans, cocoa beans, coconuts, and cloves. This has resulted in a thriving agricultural sector as companies like Nestleé procure coffee beans from the region. Population growth over the past decade in Lampung became one of the drivers of land use change from forest to residential land, agriculture, and plantations. Agroforestry is suitable to be implemented in the areas where rejuvenation in the degrading lands is needed. Coffee- and cocoa-based agroforestry systems are appealing to farmers because these crops are highly valued commodities and can create jobs (Budidarsono and Wijaya, 2004). Smallholder farmers in Lampung cultivate a variety of tree gardens, including monocultural systems, multispecies gardens, and agroforests – tree garden systems that resemble natural forests (Roshetko and Purnomosidhi, 2008).

Tanggamus district (Figure 2) currently tops the coffee and cocoa producing districts in Lampung. Coffee producing areas span around 43,941 hectare with 30,143 tons of product annually[7]. Geographic location of the survey lies in 104°18' - 105°12' East and 5°05' - 5°56' South. This particular district is selected due to its relevance with national strategy to improve coffee and cocoa productivity, as well as professional contact. I then select two top coffee- and cocoa- producing sub-districts, Sumberejo and Pulau Panggung. Data from local agricultural department listed 36 farmers' group in the area and I randomly chose 16 farmers' group covering 14 villages for the survey.

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3.2 SOCIAL EXPERIMENT: AGRICULTURAL TRAINING

The data reported here were collected in three waves, in September 2012, 2013, and 2014. In September 2012, I conducted a face-to-face interview to all household head in these 16 randomly selected coffee and cocoa farmer groups. Agricultural Department census registered 398 members in 2008, but during this baseline survey, I manage to administer the survey to 312 households (~80%). Household locations are presented in Figure 3. Different colors represent different villages, which totalled 14 villages.

7 http://tanggamuskab.bps.go.id/ accessed 2015/09/15

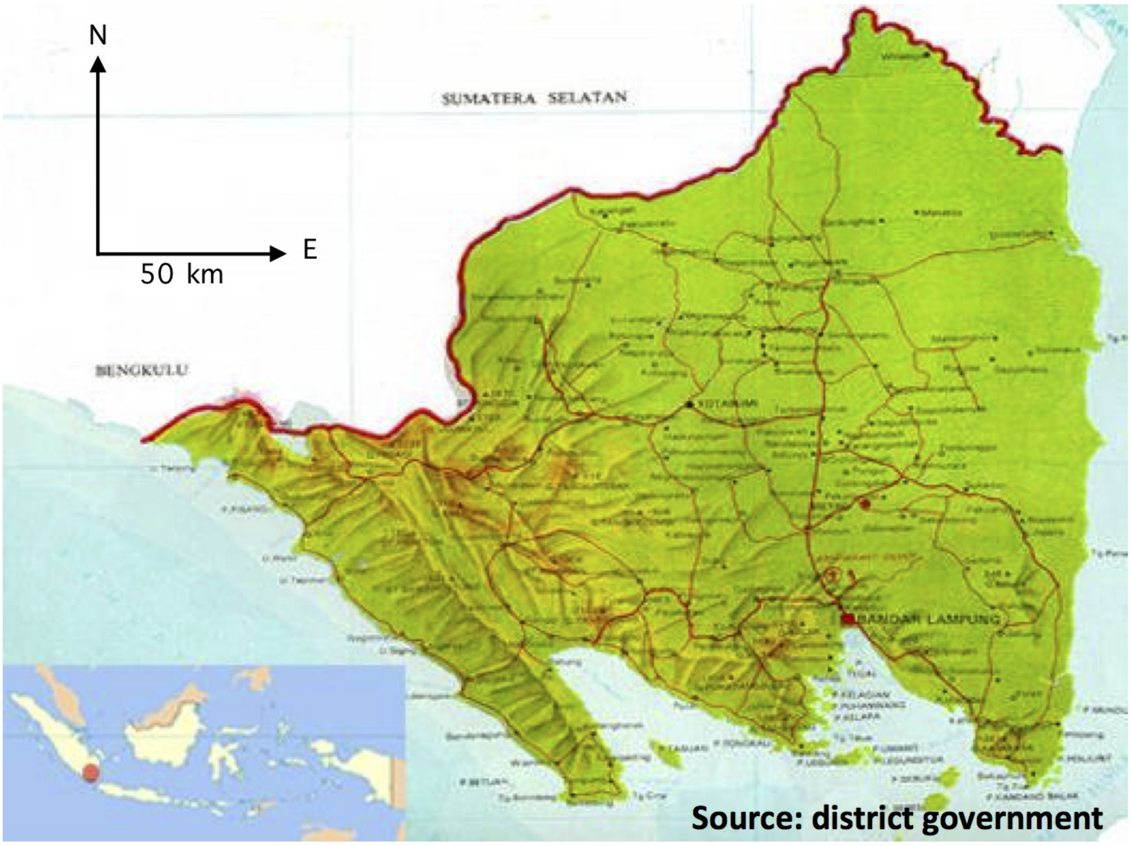

Figure 1: Map of Lampung province.

A national development program caused a high influx of Javanese migrants to resettle in Lampung between 1981 and 1997 (Elmhirst, 1999). As such, young farmers in the district are mostly second generation descendants of the migrants from Java island. Table 1 shows farmers' ethnicity and religion. Islam is the most prevalent religion embraced in the region, practiced by 97.4% population, followed by Christianity (1.6%) and Roman Catholicism (0.96%). Javanese is the district's major ethnic group (80.2%), followed by native Lampung (9.6%), Sumendo (6.7%), and Sundanese (3.2%), another ethnic group belong to the neighboring Java island.

In the study area, information disseminates through extension visit to regular farmer group meetings. Farmer's preferences for species being cultivated depend on household needs and markets (Wiersum, 2006). However, extension services generally make recommendations on new species according to biophysical criteria with less consideration

Table 1: Ethnicity and Religion

Ethnicity	Religion			Total
	Islam	Christian	Catholic	
Lampung	30 (9.61%)	0 (0%)	0 (0%)	30 (9.6%)
Javanese	243 (77.8%)	4 (1.3%)	3 (0.96%)	250 (80.2%)
Sundanese	10 (3.2%)	0 (0%)	0 (0%)	10 (3.2%)
Sumendo	20 (6.41%)	1 (0.3%)	0 (0%)	21 (6.7%)
Others	1 (0.3%)	0 (0%)	0 (0%)	1 (0.3%)
Total	304 (97.4%)	5 (1.6%)	3 (0.96%)	312 (100%)

Figure 2: Map of Tanggamus district.

on markets. Knowledge variation also exists amongst extension workers, and in some isolated area, extension coverage does not work strongly. Aside from extension workers and fellow farmers, farmer in the district almost never gets exposed to new channel of information. Critics to group-based approaches mentioned that the system works better for the non-poor than for the poor, as it sometimes tend to disadvantage farmers of lower social status who are less likely to participate in or dominate groups (Place et al., 2007).

The baseline survey carried out in September 2012 revealed that even though farmers have in fact heard of the agricultural technology examined in this study, adoption rate is still problematic. Farmers are reluctant to adopt such practices fully. Extension agents also testified that farmers have low motivation and passion to change their current farming practices. These development workers have tried many approaches to encourage farmers to implement better farming practices, including monthly group meetings to discuss problems faced by farmers and regular visits to farmers' lands. However, adoption still has not been fully embraced. Based on this information, I decided to conduct institutionalized training for randomly selected farmers from the community. Participants in the randomized training were chosen in light of several considerations:

First, I considered variations of extension-agent coverage; attention given by extension agents to farming communities varies across groups and villages. Some extension agents are considered to have more intense communication with their desig-

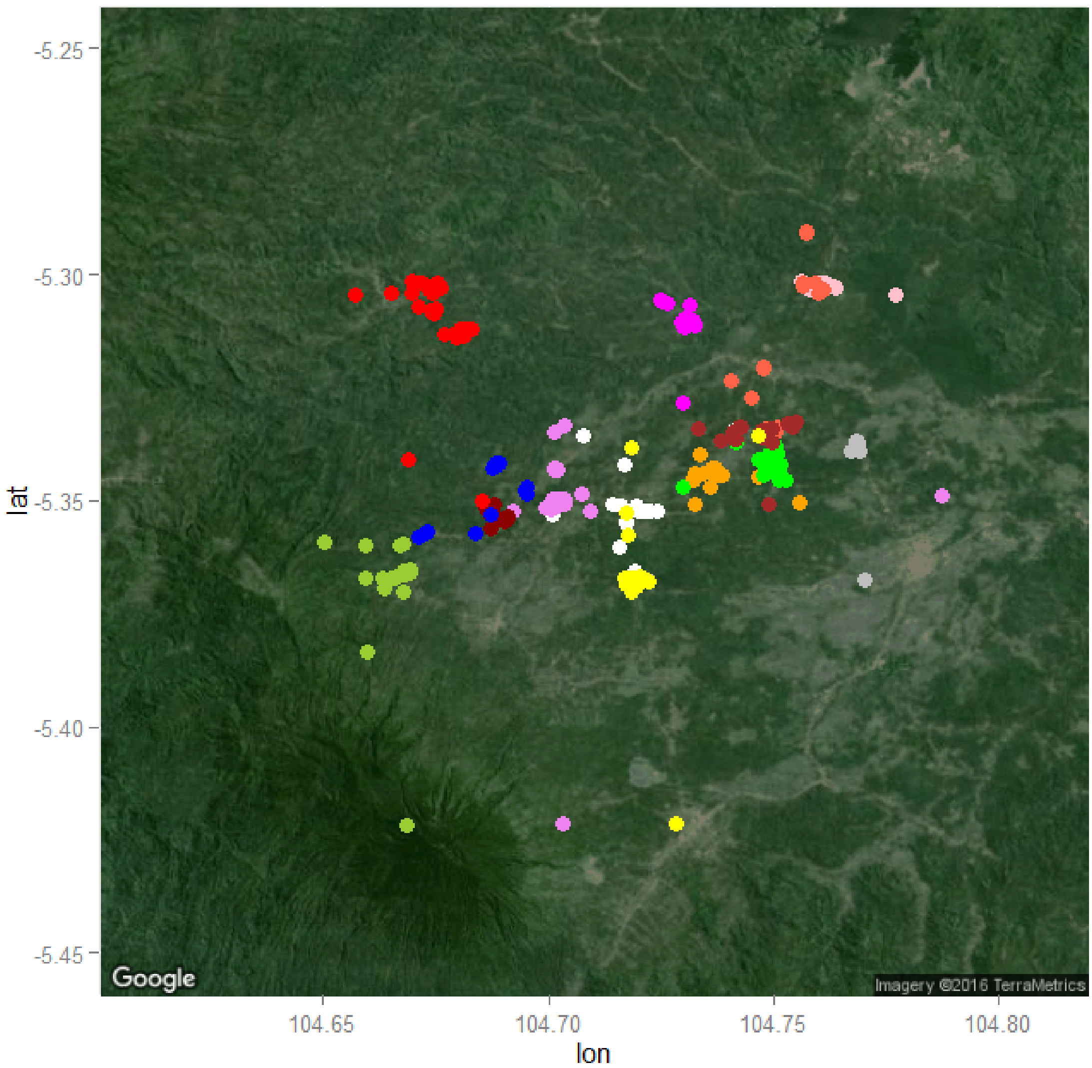

Figure 3: GPS coordinates of surveyed farmers.

nated Farming Group while others only regard the tasks as formality. Some extension agents also tend to favor particular farmers over others, particularly the most influential person in the group.

Second, no farmer in the district has undergone institutionalized training. Training, especially given by professionals from the national research institute, is usually offered to extension agents rather than farmers. These extension agents are then expected to disseminate this information to the farmers. Therefore, I am interested in conducting an intervention to see whether giving institutionalized training directly to farmers has any impact upon farmers' adoption behavior.

Third, farmers in the district are unlikely to travel frequently to the nearest big city or town. Interviews with the farmers revealed that majority rarely travel, even to the nearest big city (Bandar Lampung), a journey that takes 3 hours on average by bus. The district's farmers are unlikely to be exposed to new experiences and new environments. In this case, I examined whether changing how the training is implemented (i.e., holding it at distant places) affects farmers' adoption patterns.

In February 2013, I distribute the lottery to select 156 farmers, or 50% of the total 312 respondents, to attend a three-day training program: the first and second day would focus on training on coffee and cocoa cultivation respectively, and the last day would be spent on a field trip to a coffee-and-cocoa pilot farm. For heterogeneity purposes, I administered the training in three different locations, namely (1) in Tanggamus, the district where the farmers live; (2) in Kalianda, South Lampung, a more touristy district located around 170 km from Tanggamus but still in Lampung province; and (3) in Garut and Ciamis, the districts producing coffee and cocoa, respectively, on more developed Java Island. Similarly with Tanggamus district, South Lampung district is also famous as coffee and cocoa producing district. In the neighboring Java island however, Garut district is a major coffee producer while Ciamis district is a major cocoa producer, hence the inter-island training visited both districts in accordance to the training schedule and timeline. This randomization is performed during farmers' monthly-group meeting with their respective farmers group. Extension officials help with the randomization arrangement. The lottery states the training location where the selected farmers will undertake, and farmers take the bid by themselves. Figure 4 displays the geographical locations of the training venues and Figure 5 depicts the situation during the lottery drawing.

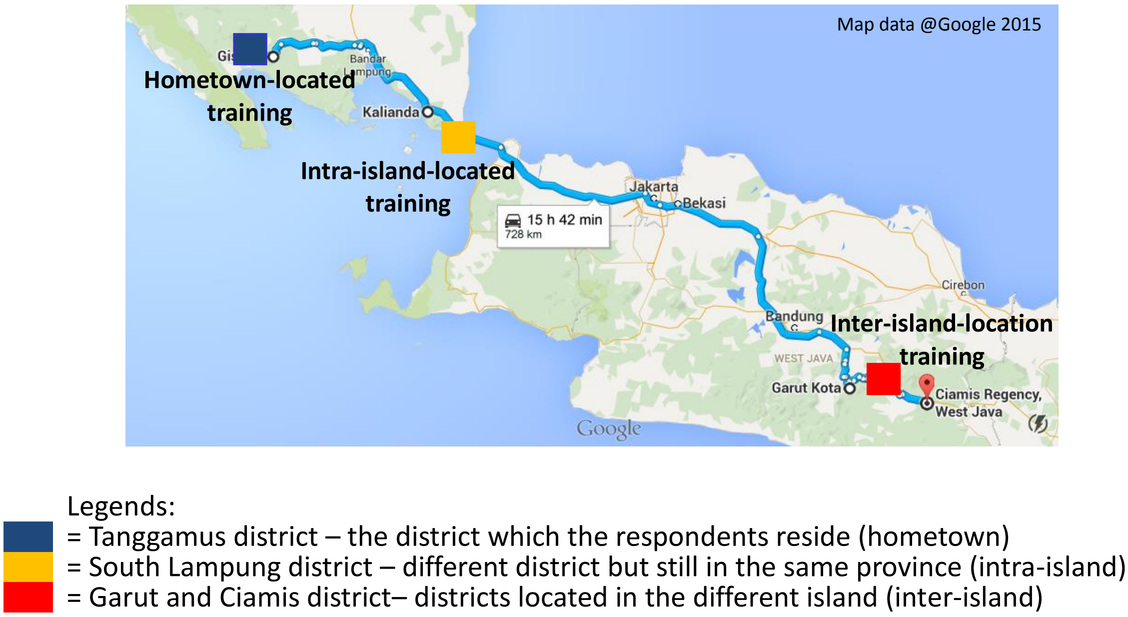

Figure 4: Geographic location of training venues.

The selected 156 farmers were randomly divided into three groups according to the location where their training would be conducted. The farmers participating in intra-island and inter-island training spent four days and three nights in total in the training center, enabling them to interact intensely with their fellow participants. The farmers were transported by land using buses, and the trip took five hours to reach the intra-island training venue and one day to reach the inter-island training location. Farmers spent a total of four days outside their villages for those trained in the intra-island location and five days for those trained in the inter-island location. The experiment was conducted carefully as the farmers' safety and wellbeing is paramount. Accommodation, food, and travel insurance during the trip and the training were provided.

The three training locations, namely the within-district, intra-island, and inter-island location, represent the field trip component (i.e. more matured and developed in terms of coffee and cocoa production, more developed as an area, extension services are more advanced) and the distance.

Figure 5: Lottery to select farmers for training program

Two professionals from Indonesian Coffee and Cocoa Research Institute (ICCRI) are invited to deliver the training program in each respective location. Training materials are kept identical across locations. Aside from in-house training, pilot farm visit is administered to the "best-practice" farm in the respective districts accordingly. Nevertheless, only training held in remote location (intra- and inter-island) incorporate the recreational activities into the training program. Farmers are scheduled to visit touristy places in intra- and inter-island location, as well as drop by in the prominent farmers' place in these locations. As such, the program was made to happen by the coordination of four district governments, as training receptions, pilot farm visit, and a short stopover at the best-practice farmers are arranged by the respective district governments. Even though the in-class training is identical across location, field trip and training experience may be different across the training groups, as the pilot farm situation and training experience are not identical.

3.3 DATA COLLECTION

3.3.1 *Research timeline*

As indicated in Figure 6, this study was carried out between September 2012 and September 2014. Baseline data were obtained in September 2012 to investigate farmers' technology level as well as their socio-economic characteristics. The 2012 baseline survey was conducted through face-to-face administration of the questionnaire to all household heads in 16 randomly selected coffee- and cocoa-producing farming groups in the district of Tanggamus, in the two sub-districts of Pulau Panggung and Sumberejo. The total num-

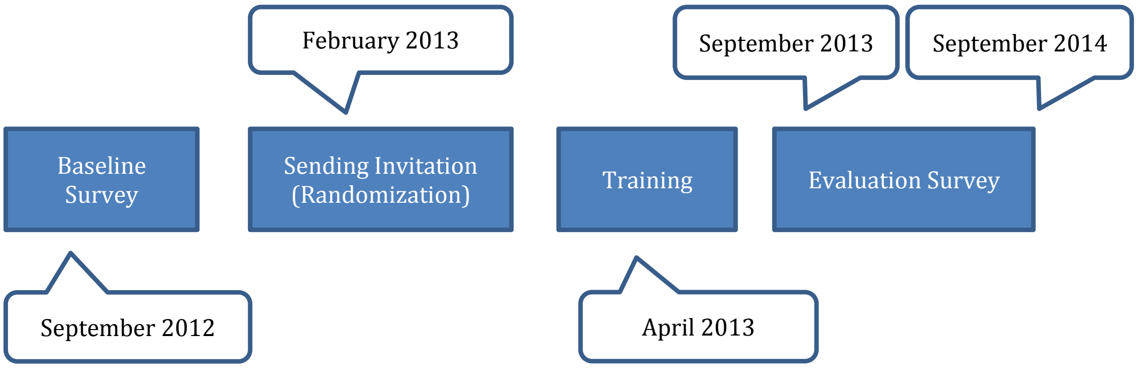

Figure 6: Timeline of the research.

ber of farmer groups in the two sub-districts is 36, and 16 farmers groups are randomly selected for the survey. These 16 farmers group listed 398 households as members in 2008, according to the latest data compiled by the local government.

During the September 2012 survey, I administered the questionnaire to 312 households (~80% of the total population). Self-identified household heads were asked to provide information on their agricultural activities, including farmland size and plants cultivated as well as details on inputs and outputs. Use of agricultural technology was the main focus, and household heads were asked to identify their current level of agricultural technology. In total, 20 pages of the questionnaire were dedicated to finding out respondents' personal and household socio-economic characteristics, including information on migration, assets, and personal-network composition.

Randomization is carried out in February 2013. During farmers' monthly group meeting in February, I rolled a lottery to invite selected farmers to join the training program. The training is conducted in April 2013, with the specific timeline: hometown training carried out first in 14 - 16 April 2013, followed by intra-island training in 17 - 20 April 2013 and inter-island training in 21 - 24 April 2013. A time gap between each training is minimized as to prevent information spillover from training participants in the nearby place to the more remote place. Training situations in hometown location (Tanggamus), intra-island location (South Lampung), and inter-island (Garut and Ciamis) are exhibited in Figure 7, Figure 8, and Figure 9 respectively.

Summary of training participation is exhibited in Table 2. There are around 11.5% of the total samples who did not show up for the training. Their absence is due to many factors, which, amongst others, are because they are engaged in other non-farming job such as street food seller, motorbike taxi, or small neighborhood shops. For these entrepreneurial groups, the cost of taking part in the training program seem to outweigh the benefits that come from it. Some other participants who did not take part mention family issues that hamper them to leave their family behind for quite sometime, and this applies particularly for farmers selected to participate in remote-location training.

Post-evaluation is conducted twice, in 2013 and 2014, making the three years panel dataset. Almost all variables are collected in each of panel year. Analysis in Chapter 4, 5, and 6 utilized the same dataset and same observation from the survey.

Figure 7: Training situation in Tanggamus (Hometown location)

Table 2: Summary of training participation

	Non-invited respondents	Invited by lottery	
		Participating respondents	Non-participating respondents
Training in hometown		39 (12.5%)	13 (4.2%)
Training in intra-island		39 (12.5%)	13 (4.2%)
Training in inter-island		42 (13.5%)	10 (3.2%)
Total	156 (50%)	120 (38.5%)	36 (11.5%)
Grand Total	**312**		

3.3.2 *Key Variables*

Key variables are collected in the three waves of surveys to all farmers, comprise socio-economic characteristics, social network, agroforestry practices, as well as agricultural technology. Some variables such as test-scores during the training were only administered for training participants and collected during the agricultural training. Details of key variables collected, altogether with explanations on what they represent, are as follows:

1. **Demographic Characteristics**
   Households' socio-economic characteristics are measured across all three waves of surveys and include assets, wealth, education, age, and occupation of all members in the households. Possession of animal such as cattle, poultry, and honey-bees are also incorporated, in addition to the size of plots and the possession of luxury goods such as motorbike, mobile phone, and electronic goods.

Figure 8: Training situation in South Lampung (Intra-island location)

2. **Test Scores as proxy for knowledge acquisition**
   Knowledge acquisition during agricultural training is investigated in the next chapter and test-scores during the training program serve as proxy for information accumulation during training. The quiz questions are identical before and after the training, and materials were loosely based on what has been taught by the instructors. This variable is available only in April 2013 during social experiment and administered only for training participants.

3. **Various Social Network Variables**
   For network variables, I solicit information regarding personal ties and advice-network ties. The former indicates whether farmers have connection with "bridging ties" or people originating from outside the community, namely extension agents and people who travel to Java island at least twice a year. Advice network ties reveal farmers' source of agricultural information in detail, as farmers sometimes like to talk and discuss regarding their farming practices to certain people. The survey asks thoroughly about such person, including frequency of meeting, years of knowing the person, mode of contact, where these people live, and whether they belong to the same farmers group. These names may be anyone, including extension workers, traders, or neighbors and relatives. Network variables are available in 3 years, except for personal ties which are only available in two waves (2012 and 2013).

4. **Agroforestry Index**
   Information on all of farmers' crops is also being sought to examine farmers' agricultural diversification strategy. Farmers are asked what they are currently cultivating in their farmland, and how long they have been planting it. In particular, the survey also incorporates detailed information on farmers' five main cash crops,

Figure 9: Training situation in Garut and Ciamis (Inter-island location)

including the total of produce sold, yield, and price for the commodity. This information is available across 3 waves.

5. **Agricultural Technology**
   Questions pertain to agricultural technology are asked in two levels: whether they know it and whether they have tried it in their farmland. Knowing means being able to do the technology correctly and step-by-step, and is a pre-requisite for adoption. When farmers have already practiced it in their farmland, they are considered to have adopted it. Data on agricultural technology is collected in all waves.

6. **GPS location of households and information on access**
   As additionalities, I record GPS location of households for further spatial analysis if necessary. Household access to the main farmland, paved road, and unpaved road, is also documented.

4

EFFECTS OF NETWORK ON KNOWLEDGE ACQUISITION: LESSONS FROM AGRICULTURAL TRAINING IN RURAL INDONESIA

4.1 INTRODUCTION

Access to information pertaining agricultural knowledge is essential to develop farmers' ability in maintaining and increasing farm productivity. Farmers who lack the means to acquire agricultural information from formal sources often rely on information within their informal social network (Boahene et al., 1999; Lyon, 2000) and transfer agricultural knowledge through social interactions (Conley and Udry, 2010). Approaches in social network posit that an individual's behavior is influenced by the kinds of relations, technical ties, and networks more than by the norms and attributes that an individual possesses (Yang and Tang, 2003). Interpersonal interaction plays significant role in facilitating learning processes as learners actively build knowledge by formulating ideas into words which is built upon reactions and responses of others. Despite the importance of network as a means for information facilitation, Newman and Dale (2005) and Bodin et al. (2006) argued that "not all social networks are created equal". They highlight the importance of distinguishing between "bonding" (interactions between family members, friends, and neighbors) and "bridging" (extend outside the community and provide access to different information and resources) ties. Balancing connections to both ties equally may improve people's economic and social well-being, including incomes (Wu and Pretty, 2004; Berrou and Combarnous, 2012), community development and survival post-natural disaster (Hawkins and Maurer, 2010), and management of collective action (Adhikari, 2008).

Some literatures have partially addressed the issue of how the social structure in a village can affect the facilitation of social learning, adoption, and the final impact on the productivity of farmers (Feder and Slade, 1984; Case, 1992; Foster and Rosenzweig, 1995; Conley and Udry, 2001; Romani, 2003). However, existing studies focus on the final adoption and little is found regarding the effects of an individual's community network structure on learning mechanism during the transfer of knowledge. Furthermore, examining learning effectiveness requires a field experimental design to fully understand the role of individual's network position in acquiring information. What the current studies are overlooking are the investigations that combine both the effects of an individual's network ties and network structure upon influencing knowledge acquisition process. I intend to fill the gap in the literatures by arguing that both are equally important during information gathering even though examination on the latter is often overlooked. My contribution is twofold:

First, I conduct a field experiment in the context of farmers' learning during agricultural training to explore the effects of social network upon farmers' learning performance. To serve the purpose, I draw a clear distinction between friendship network, as well as advice network with both "bonding ties" and "bridging ties" as key determinants for farmers' learning performance. Bonding ties are interactions between family members, friends, and neighbors in tightly connected networks, while bridging ties extend outside the community and provide access to different information and resources (Putnam, 2001;

Woolcock, 2001). Friendship network is more social-oriented in nature while advice network, despite being classified as instrumental ties, consists of relations through which individuals share resources such as information, assistance, and guidance that are related to the completion of their work.

Second, I also examine how structural properties in farmers' local network affect learning outcomes during formal agricultural training. While individual learning is undoubtedly a personal cognitive activity, it is also very likely to be influenced by social forces in that a person's everyday interactions will tend to enhance or undermine learning (Bogenrieder, 2002). To meet this objective, I investigate farmers' position in their local neighborhood, how central they are compared to others who belong to the same group, and how this affects learning outcomes.

I found that the number of ties does correspond to better learning outcomes only to some extent, but an individual's position in a farming community does strongly relate to their ability for information solicitation. Learning is shaped not simply by the number of connections, but instead by the quality of network source and its relevance to the information being sought. When advice network is not more advanced than the advisee, its effects on learning may be adversarial. On the contrary, farmers occupying central position within their community may be more familiar at facilitating problem-solving activities as they are used to conduct effective coordination of actors and resources in their local network, resulting in better learning outcomes.

The rest of the chapter is organized as follows: section 4.2 describes conceptual framework, section 4.3 explains study area's agricultural characteristics, section 4.4 explores the descriptive statistics, section 4.5 shows the empirical methodology, section 4.6 draws upon the results, and finally section 4.7 concludes with discussion and policy implication.

4.2 CONCEPTUAL FRAMEWORK

The way societies are organized and how they interact socially can have an impact upon information diffusion and farm productivity (Banerjee, 1992; Besley and Case, 1994; Foster and Rosenzweig, 1995; Conley and Udry, 2001). The essential function of networks is the exchange of information between individuals who shared social and informational resources (Carlsson and Stankiewicz, 1991). Some positive and negative network implications are assumed to be associated with an individual's performance, for instance, advice relations were positively related to entrepreneurial performance (Davidsson and Honig, 2003) and knowledge transfer (Bodin and Crona, 2009); but adversarial network has negative correlations with learning performance and motivation (Baldwin et al., 1997). While these studies offer invaluable insights to better understand the role of networks, there is still a lack of clarity on the role of social structures in determining the amount and the quality of the exchange of information among neighbors. The dimensions of such relationships in learning or advice-seeking amongst actors are not yet well understood, especially how social relationships constructed by interpersonal processes shape learning outcomes and may result in different kinds of information solicited.

In this chapter, I test whether having more network ties, be it friendship network, advice network from peers (termed "bonding ties"), or advice network from government institutions (termed "bridging ties"), can positively influence an individual's ability to perform better in knowledge acquisition during agricultural training. Furthermore, the second objective is to examine whether network centrality in farmers' locale affects their information acquisition ability. My hypotheses are as follow:

Hypothesis 1: The numbers of connections farmers have are positively correlated with knowledge attainment during training

An individual who have more connections and ties to other individuals may hold advantageous positions as these ties can serve as alternative ways to fulfill their needs, making them less dependent on other individuals. Because they have many ties, they may have access to, and be able to call on more of the resources of the network.

Hypothesis 2: Farmers who have high centrality degree will be more pro-active in knowledge seeking behavior thus performing better during learning activities.

While the first hypothesis only examines the unidirectional ties, I also provide analysis on farmers' directed networks within their local farming communities. By having information on the directions, I can distinguish one's prominence and influence within their locale and how this network position affects their information gathering mechanism. If an individual receives many ties, they are considered prominent or having high importance, as many seek to connect with them. An individual who nominates many others as their source of advice, are usually able to exchange with many others or make many others aware of their opinion. They are also often said to be influential. This important feature of Social Network Analysis can address the structural properties of social network in explaining various outcomes. Centrality, the extent to which a given individual is connected to others in a network, is the structural property most often associated with instrumental outcomes, including power (Brass, 1984), influence in decision-making (Friedkin, 1993), and innovation (Ibarra, 1993).

A very effective measure of an actor's centrality and power potential is their degree (or number of directional ties relative to everyone's scores in the locale). Few influential studies have constructed centrality measures to measure which individuals in a network hold prominent and influential roles (Freeman, 1979; Bonacich, 1972; Wasserman and Faust, 1994). Some influential studies have shown that Individual centrality in an advice network is positively associated with individual performance (Sparrowe et al., 2001). Innovations and performance can be produced if the actors occupy central network position that provide access to new knowledge developed by other units, even though it may be dependent on an individual's capacity to replicate new knowledge (Tsai, 2001).

4.3 AGRICULTURAL CHARACTERISTICS: COFFEE AND COCOA FARMING

In the study area, coffee is considered an old commodity, as most farmers reported that the farmland was inherited from the previous generation. Cocoa plantation is relatively newer, as more and more coffee farmers are converting to cocoa in the past ten years due to higher and more stable prices, and relatively low maintenance compared to coffee. In 2009, the central government announced national plan to increase productivity and cocoa commodity, called Gerakan Nasional Peningkatan Produksi dan Mutu Kakao (Gernas

Kakao)[1] with 9 provinces becoming the initial target area. In 2011, the program developed massively to target another 22 province including Lampung province. To support Gernas Kakao program, the government recruited contract assistants as extension officers who are in charge of assisting farmers and farmers group to facilitate cocoa growing activities. Extension agents were recently graduated from agricultural departments and have undertaken many forms of agricultural training established by the national recruitment team. Due to this policy, most cocoa extension workers in Lampung are much younger than coffee extension workers who have been working since long before 2011.

4.4 DESCRIPTIVE STATISTICS

The baseline survey carried out in September 2012 confirmed that farmers' primary information sources are extension workers and fellow farmers in their farmer groups. Local government officials and extension workers testified that farmers were never exposed to formal agricultural training as training is usually administered only for extension officials. Farmers in the district are also unlikely to travel frequently to the nearest city for either leisure or business. Given these facts, I decided to conduct social intervention in the form of institutionalized training to the farmers.

In April 2013, I randomly invited 156 farmers to participate in three days training: the first and second day would be the lecture on coffee and cocoa cultivation respectively, and the last day would be pilot farm visit, field trip, and visit to prominent farmers' farmland. For heterogeneity purposes, 52 farmers are invited to training located in their hometown, 52 farmers are invited to intra-island location (still in Lampung province but in different district), and the rest 52 are invited to inter-island location in the neighboring Java island.

Out of 156 invited, 120 (~80%) responded to the invitation and become the object of analysis (Table 3), consisting of 95 and 68 coffee and cocoa farmers respectively, while 47 farmers currently cultivate both. 4 farmers reported that they no longer cultivate coffee or cocoa in 2012, even though they are listed in government record as coffee and/or cocoa farmers in 2008 survey, but in the future, they may consider re-cultivate[2] The details of training participation in each location category are presented in Table 4.

Table 3: Training participants

	Non-cocoa farmers	Cocoa farmers	Total
Non-coffee farmers	4 (3%)	21 (17.5%)	25 (20.8%)
Coffee farmers	48 (40%)	47 (39.2%)	95 (79.2%)
Total	52 (43.3%)	68 (56.7%)	120 (100%)

Table 5 specifies the descriptive statistics between coffee and cocoa farmers. In general, no substantial differences are found on demographic characteristics, wealth and source of information between the two categories; however, years of experience for cultivating coffee (17 years on average) are significantly much longer than cocoa (8 years on average).

1 Source: http://ditjenbun.pertanian.go.id/tanregar/berita-164-pembukaan-peningkatan-kapabilitas-tenaga-kontrak-pendamping-tkp-gernas-kakao.html accessed 2015/12/11

2 Further examination post-training shows that out of 4 people who did not cultivate either crop in 2012, one farmer ended up cultivate both coffee and cocoa in 2013 and 2014 (after training), one farmer is found to cultivate only cocoa in 2013 and 2014 (after training), while the rest 2 farmers do not re-convert at all.

Table 4: Training participants according to location heterogeneity

Location	Category			
	Coffee farmers	Cocoa farmers	Both coffee & cocoa farmers	Neither
Hometown	30	22	15	2
Intra-island	32	22	16	0
Inter-island	33	24	16	2
Total	95	68	47	4

Cocoa farmers are also somehow more educated than coffee farmers, even though on average both did not complete middle school education. Cocoa farmers seem to also use slightly more of organic and chemical fertilizer than coffee farmers, even though coffee farmers employ more labor to some extent. I also found that around 5 farmers reported 0 hectare cultivated farmland. Further examination shows that these 5 farmers own a land, but they seem to have a contractual arrangement to lease the farmland to other farmers to cultivate coffee and cocoa. These lessee farmers will then pay the lessor farmers the agreed provision of coffee and cocoa produce after the harvest.

Table 5: Descriptive statistics

Variable	Coffee farmers only				Cocoa farmers only				Both coffee and cocoa farmers				t-test[1]	t-test[2]	t-test[3]
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max			
Demographic characteristics															
Years of experience of cultivating coffee	17.46	11.88	0	60					19.71	9.57	2	43		***	
Years of experience of cultivating cocoa					8.55	8.76	0	40	9.97	9.92	0	40		***	
Years of Education of HH Head	7.9	3.22	0	16	8.42	3.24	3	16	8.08	3.35	3	16			
Age of HH Head	44.27	11.3	21	80	44.88	9.78	28	75	46.06	10.74	28	75			
Cultivated Farmland (in Ha)	1.09	0.87	0	5	1.17	0.95	0	5	1.33	1.07	0	5			
Log of Farm Income	16.26	1.08	13.1	18.61	16.38	1.04	13.9	18.61	16.50	1.00	14.50	18.61			
Dummy Mobile Phone	0.85	0.36	0	1	0.81	0.4	0	1	0.83	0.37	0	1			
Native of Lampung[4]	0.27	0.45	0	1	0.26	0.44	0	1	0.34	0.48	0	1			
2nd Generation Migrant[4]	0.6	0.49	0	1	0.59	0.5	0	1	0.51	0.505	0	1			
No of HH members	4.23	1.7	1	12	4.27	1.73	1	12	4.6	1.87	2	12			
Male ratio in the HH	0.55	0.16	0.25	1	0.54	0.17	0.25	1	0.55	0.138	0.29	0.83			
Agricultural inputs															
No of Hired Labor	2.87	2.22	0	15	3.13	2.41	1	15	3.197	2.61	1	15			
Usage of Organic Fertilizer[5]	771.74	1079	0	5800	792.6	1018	0	4500	889	1157.8	0	4500			
Usage of Chemical Fertilizer[5]	193	232.9	0	1500	241.2	253.2	0	1500	241.48	272.13	0	1500			
Usage of Fertilizer in Total[5]	964.74	1184	0	5800	1034	1138	0	4800	1130.851	1306.32	0	4800			
Information sources															
Knowing Extension Workers[4]	0.85	0.36	0	1	0.84	0.37	0	1	0.808	0.397	0	1			
No. of Agricultural Advice Network	5.21	2.99	1	14	5.11	3.91	1	20	4.76	2.74	1	14			
No. of Advice Network Within the Farmers group	3.67	2.81	0	12	3.83	3.79	0	19	3.41	2.55	0	10			
Living nearby extension workers[6]	0.21	0.41	0	1	0.24	0.43	0	1	0.23	0.43	0	1			
Observation		**95**				**68**				**47**					

[1] *between coffee farmers (only) and cocoa farmers (only)*

[2] *between coffee farmers (only) and both coffee and cocoa farmers*

[3] *between cocoa farmers (only) and both coffee and cocoa farmers*

[4] *(= 1 if Yes)*

[5] *(in Kg/year)*

[6] *(within 15mins walking distance)*

Near-identical training was given regardless of the location. Two professional trainers from Indonesian Coffee and Cocoa Research Institute (ICCRI) were invited to give training lectures. Training materials and the lecturers were identical for each location, and trainings were controlled to produce similar environments throughout the two location-categories. Training in hometown was conducted first, and then in the different-district and inter-island location respectively. To examine learning effectiveness, farmers were given ten-question quiz before and after the lecture by the trainers. The quiz was identical before and after the lectures, and the materials were extracted from the lectures. Both quiz questions for coffee and cocoa are similar. Same weights are given to questions pertain to selecting high-yielding varieties, suitable shade-trees, grafting methods, and pruning methods. The quiz results are presented in Table 6.

Table 6: Summary statistics of the outcome variable (Test Scores)

Variable	Cocoa farmers				Cocoa farmers				t-test
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev	Min	Max	
Coffee Score (for Coffee Farmers) / Cocoa Score (for Cocoa Farmers) **Before Lecture**	3.46	2.06	0	8	7.62	1.45	4	10	***
Coffee Score (for Coffee Farmers) / Cocoa Score (for Cocoa Farmers) **After Lecture**	5.92	2.42	0	10	8.73	1.53	4	10	***
Coffee Score (for Coffee Farmers) / Cocoa Score (for Cocoa Farmers) **Differences**	2.49	2.72	-2	8	1.10	1.25	-3	4	***
Observation	**95**				**68**				

4.5 ESTIMATION METHODOLOGY

4.5.1 *Describing Social Network*

This chapter particularly addresses the effects of social network on learning performance during agricultural training. I infer that network differences will play important role during farmers' information gathering mechanism. Specifically, I am looking at the following network category:

(NT1) Friendship Network
Friendship network is defined as number of farmers from the same farmers group coming to the same training location. The results depend on the randomization process, and the data is obtained in April 2013 during the social experiment. Those who are in the friendship network, albeit coming from the same farmers group, are not necessarily in the advice network.
(NT2) Advice Network (Peers)
To solicit information regarding agricultural advice network, I asked farmers during the baseline survey in September 2012 regarding the name of person whom farmers communicating with or seeking advice pertains to coffee and cocoa farming. Amongst those names, farmers listed names that belong to the same farmers group; these names are then constructed as peers-advice network.
(NT3) Advice Network (Officials)

Similarly, the question on bridging ties is also administered during the baseline survey in September 2012. Amongst those names farmers regarded as agricultural advice network, I identified whether he or she is a government official or extension workers. Officials are considered an annex of farmers' local network. They are more advanced in terms of knowledge, experiences, and resources; and often advice farmers on farming practices. In this study I regard extension workers as bridging ties.

Network measurement in (NT1) to (NT3) only considers the number of ties farmers have and the direction is unsolicited. As additionality, I examine deeper network structures of farmers within their farming community, which places consideration on one's status, importance, and communication direction in their community.

(NT4) Network Position in Farmers' Group

Network position is measured based on information regarding advice network from inside the farmers group (peers advice network). Farmer groups usually consist of 20 to 30 farmers who have similar agriculture interests and live within the same proximity; and typically facilitate agricultural information transfer from extension workers to farmers. The group regularly conducts monthly meeting with extension workers to discuss farming practices. In group-level, farmers testify whom they obtained information from or talked to regarding agricultural practices, so the direction is outward.

According to this information, I compute several centrality measures that incorporate information on all group members' knowledge-seeking direction in the farmers group. The difference with peers-advice network (2), aside from the directional ties, is the ability to identify the individual level of importance and influence within the group. For instance, farmer No. 1 in group A may seem to be more influential when he solicited information from 10 members inside the group instead of Farmer No. 2 in group B who has sought advice from only 7 members. However, group A has 30 members while group B only has 15 members, making Farmer No. 2 more influential in his group than Farmer No. 1 even though Farmer No. 1 has more advice network.

The network structures for all 16 farmers group are plotted in Figure 10, made visualized in STATA programming by Corten (2011). The red dot represents each farmer and the blue line corresponds connection for advice network. Group 1 has many members who are very active in soliciting information from each other and the network seems dense. On contrary, there are 5 farmers in Group 7 who seem to detach from the group as they do not appear to seek advice from inside their farmers group, indicating that communication within the group is not fairly intense. Group 14 on the other hand, shows the presence of the sole influential person in the group, although the rest of group members may not look very active in information seeking from fellow members.

To measure network position within the farmers group, I utilize information from peers-advice-network (2). The information needed to construct the centrality is the identifier of the individual who initiated the advice seeking (source) and the identifier of the individual who serves as the target of the advice seeking (target) from each farmers group that become the unit of the study. I then compute three kinds of centrality measures that were initially developed by Freeman (1979) and later were translated into STATA usage by Miura (2012) and Cerulli and Zinilli (2014):

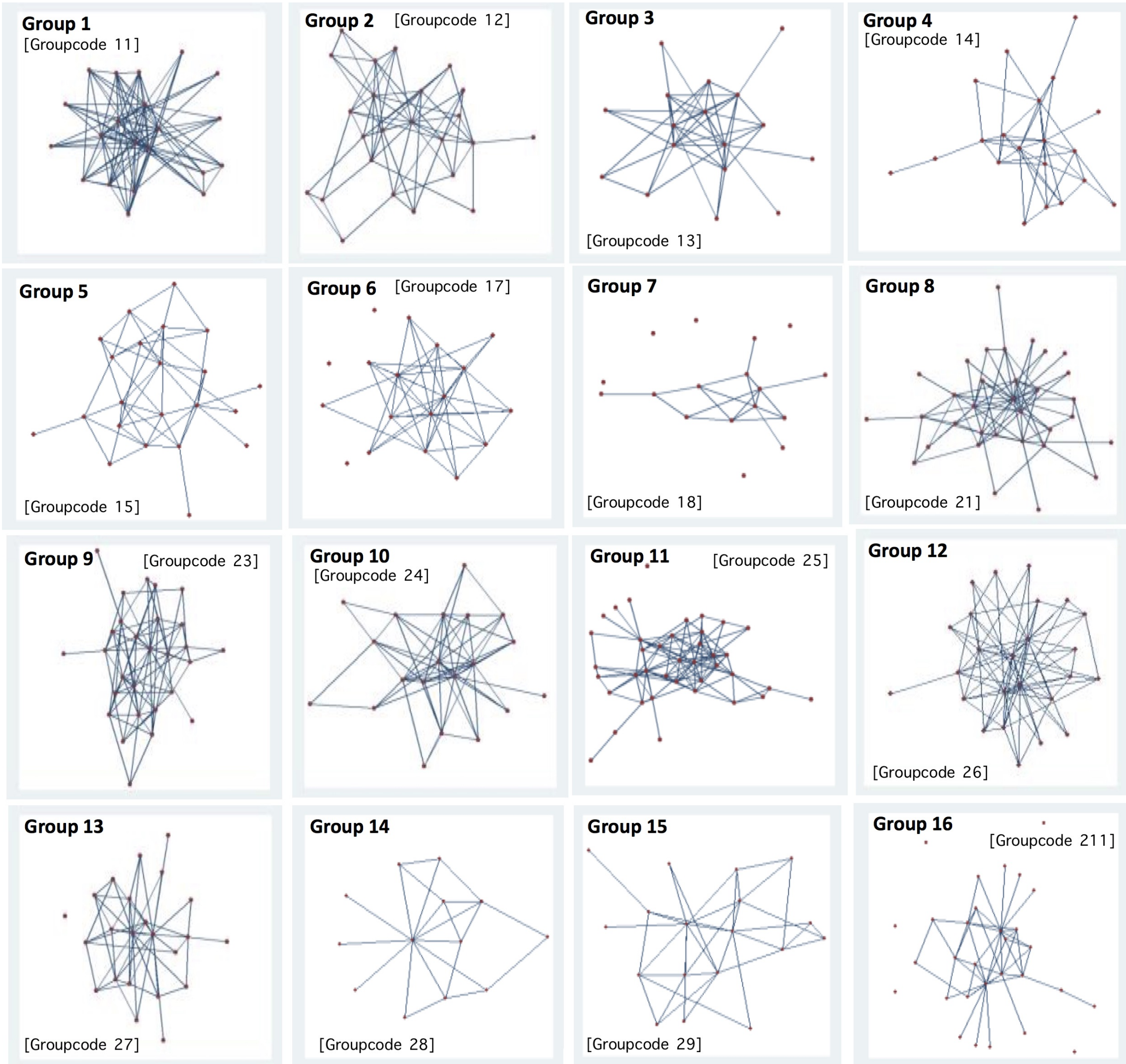

Figure 10: Network structures of all farmers group (non-training participants are included)

(NP1) Degree-centrality

Degree centrality measures the importance of a node by the number of connection the node has. An individual with a high degree centrality maintains numerous contacts with other individual and is considered influential in the group. The degree centrality is:

$$C_D(P^k)^n = \sum_{i=1}^{n} a(p_i + p_k)$$

where n is the number of nodes and $a(p_i + p_k) = 1$ if and only if node i and k are connected, and $a(p1 + p2) = 0$ otherwise.

(NP2) Closeness-centrality

Closeness is based on the length of the average shortest path between a vertex and all vertices in the graph. An individual who is close to others can quickly interact and communicate with them without going through many intermediaries. Closeness centrality is computed as the inverse of the sum of geodesic distances from node i to the g^{-1} of other node. The closeness centrality is:

$$C_C(p_k) = \left[\sum_{j=1}^{g} d(p_i, p_k)\right]^{-1}$$

where $d(p_i, p_k)$ is the geodesic distance (shortest paths) linking p_i and p_k.

(NP3) Betweenness-centrality
Betweenness is formulated based on the number of times a particular node lies "between" the other nodes in the network. It is the portion of the number of shortest paths that pass through the given node divided by the numbers of shortest path between any pair of nodes (Freeman, 1977, Borgatti, 1995). Betweenness centrality measures gatekeeping and control of information in a network and is constructed as follow:

$$C_B(p_k) = \sum_{i<j} g_{ij}(p_k)/g_{ij}$$

where g_{ij} is the geodesic distance (shortest paths) linking p_i and p_j and $g_{ij}(pk)$ is the geodesic distance linking p_i and p_j that contains p_k.

Table 7 presents summary statistics of network variables, showing that there is no substantial difference on network variables between coffee and cocoa farmers. Both farmers on average have 3 friendship connections during the agricultural training; consult with 3 farming group members; and seek advice from less than 1 extension official. For Degree-centrality measures, the highest score is 1 if they seek advice from practically everyone in the farmers group. Centrality measures show that cocoa farmers are slightly more active in information seeking albeit not statistically significant.

Table 7: Summary Statistics of Network Variables

Variable	Coffee farmers				Cocoa farmers				t-test
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev	Min	Max	
Network variables									
Friendship Network	3.54	2.22	0	8	3.51	2.16	0	8	
Advice Network (from Inside Farmers Group)	3.67	2.81	0	12	3.83	3.78	0	19	
Advice Network (Official)	0.8	1.33	0	5	0.69	1.34	0	5	
Betweenness Centrality	0.05	0.078	0	0.404	0.065	0.11	0	0.679	
Out-closeness Centrality	0.526	0.09	0.34	0.84	0.543	0.147	0.32	1	
Out-degree Centrality	0.272	0.149	0.04	0.81	0.298	0.232	0.03	1	
	95				**68**				

Network variables are often associated with education and wealth. In Table 8, OLS regressions are conducted to check the correlation between network indicators and household characteristics for coffee farmers. The results show that years of experience cultivating coffee is slightly associated with degree centrality (or the number of outward-directed ties). Education and wealth are not correlated with networks, but possession of mobile phone is, with degree- and closeness-centrality. Apparently, mobile phone serves as a catalyst connecting the ties.

Table 8: Network indicators and socioeconomic characteristics (Coffee farmers)

Variable	(1) Friendship network	(2) Advice Network (Peers)	(3) Advice Network (Official)	(4) Degree Centrality	(5) Closeness Centrality	(6) Betweenness Centrality
Years of experience of coffee farmers	-0.0124	0.0386	0.00714	0.00273*	0.00144	0.000633
	(0.0205)	(0.0260)	(0.0118)	(0.00145)	(0.000883)	(0.000779)
Years of Education of Household Head	0.00289	0.00644	0.0611	0.00649	0.00190	0.00434
	(0.0748)	(0.0946)	(0.0429)	(0.00539)	(0.00329)	(0.00290)
Cultivated Farmland[1]	0.115	-0.740*	-0.326*	0.000746	-0.00565	0.0123
	(0.307)	(0.388)	(0.176)	(0.0219)	(0.0134)	(0.0118)
Possession of mobile phone[2]	-1.189*	0.644	0.442	0.124**	0.0831***	0.0415
	(0.711)	(0.899)	(0.408)	(0.0499)	(0.0304)	(0.0268)
Possession of motorbike[2]	0.595	0.884	0.614	-0.0420	-0.0280	-0.0244
	(0.721)	(0.911)	(0.413)	(0.0563)	(0.0343)	(0.0303)
Living nearby extension workers[3]	-0.0578	-0.339	0.609*	0.0279	0.0105	0.0317
	(0.594)	(0.751)	(0.340)	(0.0423)	(0.0258)	(0.0227)
Constant	4.205***	2.447*	-0.526	0.0981	0.443***	-0.0224
	(1.060)	(1.340)	(0.608)	(0.0751)	(0.0458)	(0.0404)
Observations	93	93	93	81	81	81
R-squared	0.040	0.069	0.131	0.139	0.131	0.103

[1] *(in Ha)*
[2] *(=1 if Yes)*
[3] *(within 15mins walking distance)*

*Results are based on OLS estimation. Robust standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*

I present similar regression for cocoa farmers in Table 9 and found that education is closely related to degree-, closeness-, and betweenness-centrality. I spot different network characteristics between coffee and cocoa farmers respectively. As cocoa is a relatively young commodity compared to coffee, years of education of household head becomes an important factor to quickly master the farming practices. Contrary to cocoa farmers, possession of mobile phone becomes the primary cause of network centrality for coffee farmers.

4.5.2 *Estimation Strategy*

The estimation models for (NT1) to (NT3) as dependent variables are as follow:

1. Effect of personal network on learning effectiveness

$Y_{i,t} = \alpha + \beta_1 Time_{i,t} + \beta_2 AdviceNetwork_{i,t} + \beta_3 Time * AdviceNetwork_{i,t} + \beta_4 X + u_{i,t}$ if Coffee/Cocoa farmers = 1

for (1), where i indexes each farmers' id; Y_i is an outcome variable of interest, namely the coffee and cocoa quiz scores for either coffee or cocoa farmers; α_i is constant; Time is indicator of pre- and post-training period (that is Time = 1 for post-training and 0 for the otherwise); Network is the number of social ties farmers have; and u_i is a random error term. I use the quiz score before and after in Y and conduct panel analysis as the panel nature takes into account the time invariant heterogeneity. Network with peers

Table 9: Network indicators and socioeconomic characteristics (Cocoa farmers)

Variable	(1) Friendship network	(2) Advice Network (Peers)	(3) Advice Network (Official)	(4) Degree Centrality	(5) Closeness Centrality	(6) Betweenness Centrality
Years of experience of cocoa farmers	0.0313	0.0241	0.0354*	-0.00424	-0.00260	-0.00276*
	(0.0330)	(0.0568)	(0.0202)	(0.00346)	(0.00220)	(0.00164)
Years of Education of Household Head	-0.0948	0.139	0.0354	0.0269***	0.0166***	0.00894*
	(0.0827)	(0.142)	(0.0507)	(0.00947)	(0.00603)	(0.00449)
Cultivated Farmland[1]	0.189	-0.816	-0.345	0.0137	0.000363	0.0223
	(0.343)	(0.591)	(0.210)	(0.0379)	(0.0241)	(0.0180)
Possession of mobile phone[2]	0.321	-1.284	0.293	-0.0112	0.00522	0.0515
	(0.764)	(1.386)	(0.494)	(0.0909)	(0.0579)	(0.0432)
Possession of motorbike[2]	0.839	-2.621	0.344	-0.110	-0.0906	-0.00314
	(0.930)	(1.614)	(0.575)	(0.107)	(0.0680)	(0.0507)
Living nearby extension workers[3]	-0.514	-0.334	0.549	0.0287	-0.00533	0.0885**
	(0.659)	(1.144)	(0.407)	(0.0741)	(0.0472)	(0.0352)
Constant	2.980**	6.857***	-0.208	0.196	0.505***	-0.0710
	(1.274)	(2.196)	(0.782)	(0.143)	(0.0911)	(0.0679)
Observations	67	66	66	57	57	57
R-squared	0.086	0.124	0.120	0.194	0.194	0.210

[1] *(in Ha)*
[2] *(=1 if Yes)*
[3] *(within 15mins walking distance)*
*Results are based on OLS estimation. Robust standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*

and experts do not change across waves. The variable of interest is the interaction term between Network and Time; as I attempt to see how network plays role during information gathering during agricultural training. For this regression, I construct different estimation for both coffee and cocoa farmers respectively and utilize random-effects estimation for our model. In cases where the key variables (x_t) do not vary much overtime, the random-effects model can take account the effect of time-constant variable in the panel data study thus efficiently account for any remaining serial-correlation due to unobserved time-constant factor (Wooldridge, 2010).

For various network positions (NP1 - NP3) as dependent variables, the estimations are as follow:

2. Effect of network position on learning effectiveness (only if farmers mention any member in their farmers group as agricultural advice network)

$Y_{i,t} = \alpha + \beta_1 Time_{i,t} + \beta_2 Centrality_{i,t} + \beta_3 Time * Centrality_{i,t} + \beta_4 X + u_{i,t}$ if Coffee/Cocoa farmers = 1

For (2), Y_i is the coffee and cocoa quiz scores for either coffee or cocoa farmers; Centrality is the measure of closeness centrality, degree centrality, and betweenness centrality; similarly with the above, α_i is constant; Time is indicator of pre- and post-training period (that is Time = 1 for post-training and 0 for the otherwise). For this estimation, the variable of interest is the interaction term between Centrality measures and Time, indicating the influence of one's network position in their community upon their learning achievement.

4.6 ESTIMATION RESULT

4.6.1 *Effect of Personal Network on Learning Performance*

Table 10 column 1 to 4 presents regression results of the influence of personal network on knowledge acquisition for the case of Coffee farmers. I found that for every peers- and expert- (official) advice network a farmer participant has, the test-score post-training will likely to be higher by 0.29 points and 0.15 points out of 10 points respectively. Conversely, having one friend from the same farmers group joining the training, farmers' score will be likely to drop by 0.05 points. Coffee farmers having more friendship ties also have lower score by 0.1 points to begin with, indicating the negative effects of social ties on learning performance. In general, farmers having association with government agents also seem to have lower scores before the training by 0.29 points even though the score increments are significantly higher post-training.

As coffee is considered an old commodity, knowledge regarding coffee production has been revolving across generations. There is not much new innovation and information regarding coffee production; and there is possibility that the provision of the current knowledge may probably be wrong to some extent. As extension agents for coffee commodity are tenured government officials and are much older than cocoa's extension workers who are mostly fresh-graduated; they may be less likely to get the newest update and innovations regarding coffee practices. This may be why coffee farmers who seek advice from extension agents generally obtain lower scores, even though post-training, the scores are significantly higher as they are already familiar and adept with coffee production.

Additionally, living nearby extension agents and possession of motorbike contribute positively for knowledge attainments; indicating the importance of access to retain knowledge.

Results for Cocoa farmers are reported in columns 5 to 8. For every peers- and government-advice network farmers have, the coefficient post-training is lower by 0.01 points and 0.28 points respectively. And for every friendship ties, the coefficient will drop by 0.09 points. At the beginning, it may seem that peers-advice network and friendship network have negative association with learning performance. However, in column 5 and 6, the coefficient on friendship network and peer-advice network are positive and significant by 0.02 and 0.09 points respectively, meaning that the scores of farmers who have more of this network were higher from the beginning. Farmers with more peers- and friendship-networks may possibly know the cocoa production better relative to others; hence the increment on the score from the training is smaller than others with fewer networks. On the other hand, farmers with less of these networks learned a lot more from the training because they didn't know it well before. Cocoa is newer, so people don't know it as much as coffee, but those with more networks know it better before the training.

This finding confirms that the first hypothesis is only partially correct, while advice networks are almost always beneficial, friendship network in classroom settings may hurt learning outcomes. Friendship network is found to have negative spillover for learning achievements, as it applies to both coffee and cocoa farmers equally. For each friendship network, participants' scores post-training will get lower by 0.05 and

Table 10: Effects of network ties on knowledge acquisition

	Coffee Score (if Coffee Farmers = 1)				Cocoa Score (if Cocoa Farmers = 1)			
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Time*Friendship Network	-0.0514***			-0.112***	-0.0955***			-0.0668***
	(0.00571)			(0.00335)	(0.000372)			(0.000170)
Time*Advice Network (Peers)		0.292***		0.295***		-0.0129***		-0.0277***
		(0.00309)		(0.00329)		(0.000278)		(0.0001)
Time*Advice Network (Official)			0.158***	0.121***			-0.289***	-0.269***
			(0.00369)	(0.00127)			(0.00019)	(0.00038)
Friendship Network	-0.102***			-0.0747***	0.0234***			0.0770***
	(0.00878)			(0.0242)	(0.00727)			(0.00962)
Advice Network (Peers)		-0.0445		-0.0256		0.0875***		0.0937***
		(0.0526)		(0.0496)		(0.00681)		(0.00857)
Advice Network (Official)			-0.294**	-0.236**			-0.0448	-0.0517
			(0.127)	(0.0996)			(0.0291)	(0.0338)
Time (= 1 if Post-lecture)	2.623***	1.364***	2.322***	1.662***	1.444***	1.444***	1.278***	1.605***
	(0.0600)	(0.0490)	(0.0415)	(0.0590)	(0.00466)	(0.00242)	(0.00076)	(0.00140)
Years of Experience of Coffee Farmers	0.00163	0.00108*	0.00590	-0.0021***				
	(0.00382)	(0.00064)	(0.00481)	(0.000295)				
Years of Experience of Cocoa Farmers					0.0121**	0.0107**	0.018***	0.0151**
					(0.00573)	(0.00474)	(0.00687)	(0.00753)
Years of Education of Household Head	0.0842	0.0861	0.102	0.0976	0.123***	0.111***	0.129***	0.121***
	(0.0785)	(0.0774)	(0.0803)	(0.0825)	(0.00932)	(0.00354)	(0.0005)	(0.00134)
Cultivated Farmland[1]	-0.000668	0.0510	-0.1050	0.0241	-0.2280	-0.1720	-0.308***	-0.249***
	(0.410)	(0.338)	(0.435)	(0.341)	(0.147)	(0.127)	(0.0965)	(0.0943)
Possession of Motorbike[2]	1.083***	0.946***	1.172***	1.062***	-0.1050	0.0466	-0.1190	0.0572
	(0.111)	(0.207)	(0.0645)	(0.206)	(0.637)	(0.751)	(0.682)	(0.722)
Possession of Mobile Phone[2]	-0.737**	-0.609**	-0.4690	-0.761***	-0.0668	0.1550	0.0880	0.19400
	(0.326)	(0.291)	(0.382)	(0.239)	(0.0904)	(0.125)	(0.164)	(0.1300)
Living Nearby Extension Agents[3]	0.5140*	0.587**	0.630**	0.650***	-0.3610	-0.2650	-0.2300	-0.16300
	(0.304)	(0.256)	(0.299)	(0.235)	(0.275)	(0.215)	(0.175)	(0.2330)
Trained Outside Hometown[2]	-0.4240	-0.2430	-0.3550	-0.3640	-0.218**	-0.236**	-0.300***	-0.289***
	(0.724)	(0.644)	(0.728)	(0.675)	(0.110)	(0.110)	(0.0719)	(0.0707)
No. of Extension Agents Present During Training	0.2810	0.2950	0.2590	0.3400	0.00785	0.0553**	0.000497	0.0260***
	(0.350)	(0.311)	(0.356)	(0.301)	(0.0188)	(0.0220)	(0.00934)	(0.00618)
Constant	1.3440	0.8770	0.8560	1.0670	6.981***	6.152***	7.033***	6.005***
	(2.213)	(2.246)	(2.281)	(2.201)	(0.262)	(0.284)	(0.230)	(0.394)
Observations	174	174	174	174	131	129	129	129
Number of year	2	2	2	2	2	2	2	2
R-squared	0.295	0.323	0.296	0.347	0.220	0.246	0.247	0.279

[1] *(in Ha)*

[2] *(=1 if Yes)*

[3] *(within 15mins walking distance)*

*Results are based on Random-Effects estimation. Clustered robust standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*

0.09 points for coffee and cocoa farmers respectively. Even though for cocoa farmers, those with friendship connections already have higher scores to begin with. This findings support Bandiera et al. (2010)'s study who find that workers having no social ties with their co-workers are significantly more productive at work compared to those having social ties. Years of education and years of experience cultivating cocoa also seem to have significant effects on test scores.

4.6.2 *Effect of Network Position in a Community on Learning Performance*

Delving deeper into farmers' network structure in their respective farmers group, further examination is conducted on how it affects learning during training. In Table 11, I found that all three network variables, namely degree-, closeness-, and betweenness-centrality are strongly correlated with higher test-scores for both coffee and cocoa farmers respectively. The highest possible closeness- and degree- centrality score attained is 1 if farmers practically mention everyone in their farmers group as source of agricultural advice. After the training, farmers who were close to all people in their group and listed everyone as sources of advice, tend to obtain 1.3 points and 1.6 points higher respectively for coffee farmers, and 0.5 points and 0.04 points for cocoa farmers.

The result indicates that farmers with a high degree of centrality may be very good at adapting themselves in unknown situation and environment thus supporting the second hypothesis. Farmers who inhibit the central position in their communities are found to possess innate abilities to do better problem-solving, making them more productive during learning activities even in foreign environment.

4.7 DISCUSSION AND POLICY IMPLICATION

This chapter explores how farmers' social network affects their information acquisition ability. To serve the purpose, I conducted a quiz before and after agricultural training and see how various social network variables influence learning outcomes. I distinguished social network ties into bonding and bridging ties, as well as, looked at farmers' network structure within their farming group community. This study found that the number of ties does correspond to better learning outcomes only to some extent, but an individual's position in a farming community strongly relates to their ability for information solicitation. Findings in details are discussed as follow:

First, friendship network during agricultural training may hurt learning performance to some extent. Friendship network leads to lower knowledge acquisition throughout the program for coffee farmers, even though for cocoa farmers, those with friendship networks have higher scores to begin with. Coffee farmers may think that they are familiar already with the farming practices, hence social ties during training hurts their productivity and concentration. This finding is similar with Bandiera et al. (2010) who found that social ties at work actually hurts productivity compared to not having social ties at all.

As cocoa is a newer commodity, cocoa farmers may be more interested in the training; thus stronger learning effects can be spotted as farmers having more friendship ties generally enjoy higher scores. Cocoa farmers with more friendship and peer-advice networks may possibly know cocoa production better relative to others; hence the increment

Table 11: Effects of network position in farmers group on knowledge acquisition (only for farmers who mentioned any group members as advice network)

	Coffee Score (if Coffee Farmers = 1)			Cocoa Score (if Cocoa Farmers = 1)		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Time*Closeness Centrality	1.315***			0.526***		
	(0.585)			(0.000417)		
Time*Out-degree Centrality		1.682***			0.0485***	
		(0.402)			(0.00108)	
Time*Betweenness Centrality			4.044***			1.273***
			(0.198)			(0.00907)
Closeness Centrality	4.121***			1.057***		
	(0.725)			(0.0116)		
Out-Degree Centrality		1.399***			0.990***	
		(0.499)			(0.00827)	
Betweenness Centrality			-0.798***			2.493***
			(0.113)			(0.635)
Time	1.869***	2.102***	2.336***	0.857***	1.128***	1.064***
	(0.367)	(0.170)	(0.0685)	(0.00327)	(0.00370)	(0.00318)
Years of Experience of Coffee Farmers	0.00124	0.00262	0.00814**			
	(0.00373)	(0.00259)	(0.00355)			
Years of Experience of Cocoa Farmers				0.00569	0.00667***	0.0101
				(0.00351)	(0.00230)	(0.00774)
Years of Education of Household Head	0.0666	0.0614	0.0725	0.0727***	0.0668***	0.0694***
	(0.0921)	(0.0879)	(0.0819)	(0.0124)	(0.00807)	(0.0188)
Cultivated Farmland[1]	-0.000938	-0.0322	-0.0411	-0.310**	-0.323**	-0.386***
	(0.590)	(0.591)	(0.613)	(0.128)	(0.132)	(0.0872)
Possession of Motorbike[2]	1.394***	1.372***	1.305***	-0.33200	-0.33800	-0.43500
	(0.0332)	(0.0139)	(0.00194)	(0.66600)	(0.69300)	(0.67600)
Possession of Mobile Phone[2]	-0.849**	-0.697**	-0.43800	0.306***	0.328***	0.137***
	(0.350)	(0.292)	(0.26900)	(0.0854)	(0.0848)	(0.0236)
Living Nearby Extension Agents[3]	0.607***	0.623***	0.699**	-0.14800	-0.18100	-0.436*
	(0.203)	(0.231)	(0.286)	(0.15500)	(0.16300)	(0.255)
Trained Outside Hometown[2]	-0.33100	-0.26900	-0.18500	-0.164*	-0.170**	-0.0741
	(0.70400)	(0.72500)	(0.701)	(0.0880)	(0.0798)	(0.134)
No. of Extension Agents Present During Training	0.15200	0.17300	0.17300	0.00443	0.0114	0.0277
	(0.475)	(0.472)	(0.461)	(0.0182)	(0.0189)	(0.0270)
Constant	-0.48500	1.07200	1.10000	7.021***	7.313***	7.596***
	(3.306)	(3.150)	(3.000)	(0.320)	(0.325)	(0.346)
Observations	150	150	150	111	111	111
Number of year	2	2	2	2	2	2
R-squared	0.332	0.325	0.313	0.240	0.245	0.267

[1] *(in Ha)*
[2] *(=1 if Yes)*
[3] *(within 15mins walking distance)*
*Results are based on Random-Effects estimation. Clustered robust standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*

on the score from the training is significantly smaller than others with fewer networks. Those with fewer networks learn more during the training.

Friendship network such as those examined in this research represent the network "capital" that farmers have. Unfortunately, this study has the limitation to quantify to what extent fellow participants are communicating with their peers from the same community and to what extent the knowledge is transferred through communication during the training.

Second, the quality of advice network upon information solicited matters for learning facilitation to some extent depending on their years of experience. Mixed findings are found between coffee and cocoa commodity. Further examination found significant difference in the years of experience of the advice network between these two commodities, which may affect participants' learning outcomes. Several possibilities arise on why knowledge-seeking characteristics are different between coffee and cocoa farmers, and more importantly, why advice network seems to have negative associations on cocoa farmers' information seeking behaviour during agricultural training:

1. For coffee farmers, having government official as advice network is associated with lower test-scores in general. As extension agents for coffee commodity are tenured government officials and are much older than cocoa's extension workers; they may be less likely to get the newest update and innovations regarding coffee practices. This is why coffee farmers who seek advice from extension agents generally obtain lower scores, even though post-training, the scores are significantly higher as coffee farmers are already familiar and adept with coffee production.

2. Cocoa extension workers in the area are still inexperienced compared to coffee extension workers. The Gernas Kakao program, which was implemented in early 2011, assigned contract workers with degree in agricultural sciences. In Tanggamus district, cocoa extension workers, despite being an official, are still considered less-experienced. Most of cocoa extension workers are recently recruited and freshly graduated. This probably explains why having network with cocoa extension workers result in negative spillover on test scores.

Third, different pattern of knowledge acquisition behavior is identified, depending on the nature and characteristics of the commodities. Coffee is an old commodity in the area and cocoa is relatively new. Many farmers, despite cultivating cocoa and/or have converted some provisions of their farmland for growing cocoa, are still not familiar with its farming practices. Majority planting cocoa can still be considered a "novice" compared to coffee. This is why individual characteristics such as years of education (ability) and years of cultivating (skill) become two important determinants of cocoa test scores, while not so much on network.

Nevertheless, living nearby extension agents and possession of motorbike seem to strongly influence coffee scores but not cocoa scores. Being an old commodity, the increase in coffee scores post-training is strongly affected by the possession of motorbike and whether the farmers live nearby extension workers. Motorbike possession can be considered a proxy for reaching "bridging ties" outside their neighbourhood to search for new information, including to access possible information sources such as traders and government workers.

On contrary, increase in cocoa scores post-training is influenced by individual characteristics such as years of education and possession of mobile phone. Mobile phone has longer coverage than motorbike connecting farmers to outside world, indicating that the tool can possibly be an information gathering means that could reach even better and more advanced "bridging ties".

Fourth, one's position in their network structure in a community contributes positively to learning outcomes. Farmers who are in the central position in their farmers group are strongly associated with higher test scores post-training. Farmers with a high degree of centrality may be very good at facilitating problem-solving activities as they are used to conduct effective coordination of actors and resources in their local network. They are more adept in solving problem even in the previously unknown environment, thus perform better in learning during agricultural training.

While it is easier for future information dissemination strategy to approach influential farmers to help distributing new information in their local community, networks which have few members with very high centrality measures may have adversarial effects on learning, as it reduces the access of other actors to multiple sources of information (Abrahamson and Rosenkopf, 1997). Another implication from this study is that informants serve as "bridging ties" should preferably be more experienced and advanced than the advisee so that learning could be better facilitated and the risk of transferring wrong knowledge could be minimized.

5

EFFECTS OF VARYING TRAINING LOCATIONS ON AGRICULTURAL TECHNOLOGY DIFFUSION, ADOPTION, AND SOCIAL NETWORK

5.1 INTRODUCTION

Social learning has been the focus of interest in recent years and is becoming a norm in disseminating knowledge and information regarding natural resource management and policy (Reed et al., 2010; Muro and Jeffrey, 2008; Warner, 2007). Learning effects, both from extension agents and from fellow farmers, exert significant influence over technology-adoption decisions (Cramb and Culasero, 2003; Klerkx et al., 2010; Prell et al., 2010; Moser and Barrett, 2003). Ties to extension agents, in particular, significantly contribute to improvements in smallholder farmers' access to information, which will eventually culminate in their adoption of better agricultural practices (Tefera and Sterk, 2010; Pretty et al., 2011; Yorobe et al., 2011). At the same time, learning from peers also contributes significantly to the decision to adopt a technology, even though the learning direction is not clearly specified (Conley and Udry, 2010; Foster and Rosenzweig, 2010; Matuschke and Qaim, 2009).

Several previous studies have examined social learning in formally organized settings such as participatory workshops or similar activities (Schusler et al., 2003; Fitzpatrick et al., 2008; Dalsgaard et al., 2005; Kijima et al., 2012). In principle, learning is triggered when different stakeholders meet and interact with each other, and can be said to have happened when a change is manifested in the attitudes and beliefs of those in participating in the session (Rodela, 2011). To date, many empirical studies involving social learning and technology adoption have been conducted; of those utilizing micro-level data, the most notable are in Munshi (2004); Bandiera and Rasul (2006); Duflo et al. (2008); Conley and Udry (2010).

Despite many efforts to encourage technology adoption through social learning, finding ways to introduce methods of adoption to gradually alter the perception, attitudes, and behavior of individuals and institutions involved has proven to be the key challenge and a prescription for successful adoption (Glendinning et al., 2001). Existing literatures on informal social learning are not adequate to explain the linkages between various network mechanism and technology adoption, especially when social intervention such as formal agricultural training is taken into equation. Formal institutions, such as institutionalized agricultural training conducted in this study is necessary to advance farmers' knowledge regarding better agricultural practices. However, adoption of technology takes much more than simply the possession of knowledge, as adoption necessitates encouragements from many parties. Unfortunately, such mechanisms are yet to be fully understood.

This study seeks to provide more evidence of the effect of institutionalized training and the relationship of interplay between technology adoption and links to peers and experts as well as to explore various social learning mechanism amongst peers and with experts.

The first objective of this study is to examine the effect of social learning derived from formal agricultural training conducted in different locations. It incorporates the location-heterogeneity effects into its model to capture the different experiences obtained by participating farmers. I examine technology adoption, and ties with experts and peers between groups who trained in their home locations versus those who trained far away. By using such a methodology, I expect to see the corresponding effects of experiences in different workshop locations via their different influences on farmers' social learning, which will eventually be reflected in their adoption behavior.

The second objective is to investigate the factors affecting agricultural-technology adoption. The technologies I examine include soil- and water-conservation technology, plant-rehabilitation technology (consisting of both side-cleft and bud grafting), and usage of chemical and organic fertilizers. All of the technology are considered very relevant with the biophysical criteria of the study location and are important to increase productivity.

The third objective is to explore the possibilities whether farmers who occupy the central position in their local neighborhood are more likely to acquire better knowledge than farmers who inhabit the less central position. While ex-ante studies on network mostly put emphasis on the number of ties (non-directional), this study offer unique contribution to examine farmers' directional ties within their locale.

The fourth objective is to test whether information diffusion takes place from training participants to non-training participants upon return. As farmers who undertook the training will obtain more knowledge relative to their non-participating counterparts, I expect to see the effects of training upon non-participating respondents and to explain how such mechanism takes place.

I found that training in general helps enhance farmers' knowledge regarding better agricultural techniques. Farmers who participated in the training held at the most remote location showed the largest impact of training, particularly in terms of the soil- and water-conservation technique. I find the evidence that training conducted on a neighboring island actuates stronger social learning from extension agents and fellow farmers. This interplay of social learning with peers and experts is consequently reflected in farmers' adoption behavior.

Mixed findings are found between training participants' centrality measures and the knowledge to implement plant-rehabilitation technique. Although in general, regardless of training participation, farmers who are more influential in their locale have better information processing hence are adept at embracing complex agricultural information and pushing the usage of fertilizer.

Lastly, information spillover is found between training participants to non-participants post training. Amongst all farmers in general, networking with inter-island training participants is found to help increase likelihood to eventually use both organic and chemical fertilizer. For the non-training participants, having ties with training participants are associated with higher likelihood to use the fertilizer to some extent.

The rest of the study is organized as follow: section 5.2 describes the conceptual framework, section 5.3 describes Indonesia's agricultural situation, section 5.4 presents the descriptive statistics, section 5.5 discusses the estimation strategy, section 5.6 draws on the estimation result, and section 5.7 concludes with discussions and policy implication.

5.2 CONCEPTUAL FRAMEWORK

This chapter aims to look at the effect of social learning as elicited from experiences in different training locations upon the diffusion and adoption of agricultural techniques. I compare technology adoption and various network variables between groups who trained in their home location versus those who trained in more remote places namely intra-island and inter-island locations. My hypotheses are as follow:

Hypothesis 3: Attending an agricultural training will become more effective for knowledge acquisition if the training is carried out at a remote place, farther away from the participant's original location.

Participants who travel away from their native community for the purpose of knowledge-seeking are more likely to work harder upon returning from the training program. Training held in a remote location will strengthen participants' relationships between others from the same training group. For farmers living in an isolated rural district, going to a faraway place to participate in formal training is indeed a challenge. These feelings of adversity may generate deeper social learning among fellow participants in the inter-island training category, relative to other participants who undertook training in more familiar places, thus will result in stronger social learning with fellow farmers post-training. I expect training participants who trained in remote-location to acquire better knowledge regarding farming practices after returning from the training relative to those trained in the nearby places.

Hypothesis 4: Farmers who train at an inter-island training location (most remote area) will acquire the most knowledge and experience, and are therefore the most likely to adopt new technology.

Knowledge is a pre-requisite for technology adoption, and is therefore becoming an utmost factor in driving the adoption. As inter-island training participants are expected to acquire the most information, they are also possessing higher likelihood to adopt the technology due to the increased knowledge. Apart from the improved knowledge, training held in remote-location with recreational activities embedded, will hypothetically motivate farmers and change their attitudes. After returning from the training, these farmers may talk more with their agricultural informants and increase the size and depth of their rural network. The training experience may excite them to initiate communication with others. Adoption needs encouragements from many parties in order to take place, hence more network and ties are necessary to propel it.

For technologies that require some level of technical knowledge such as grafting methods, having direct and frequent contact with extension services increases the acquisition of relevant knowledge (deGraft Johnson et al., 2014). Similar results that report a positive impaction between the contact with extension workers and the rate of technology adoption can also be found in Amare et al. (2012). Inter-island training participants are expected to enlarge their size of networks both with their peers and experts, namely extension workers. This stronger intensity of communication with agriculture experts will exert technology adoption behavior post-training.

Hypothesis 5: Farmers who occupy the central position will acquire the most knowledge and are therefore the most likely to adopt new technology.

While many studies have examined the role of non-directional ties to actuate social learning, such role of directional ties are rarely inspected. Information on the direction is mandatory to appraise one's importance in their local farming communities. An individual who nominates many people as their source of advice may be considered influential, as they are usually able to exchange information and ideas with their community members and make others aware of their opinion. Agrarian actors who are central in their network are usually prominent; thus are more likely to have better information processing skill. Those who occupy the central position in their community are expected to have better understanding regarding agricultural technology and therefore are more likely to be an early adopter.

Hypothesis 6: Information spillover from training participants to non-participants are present, which helps spur the diffusion and adoption of technology for the non-participants.

Upon returning from the training, training participants are expected to talk more with their agricultural advice network as they may be likely to showcase the experience they obtained from the training. As information is embedded in social interactions (Granovetter, 1973), knowledge is also more plausible to be transferred from training participants to non-participants. I expect to see knowledge improvement and more adoption for non-training participants.

5.3 AGRICULTURE CHARACTERISTICS AND TECHNIQUES

The area's most prevalent problems are aged plantations and traditional farming systems. Thus, revitalization of these farms' plants is deemed necessary. Most plantations were the legacy of smallholders' parents or grandparents, dating back to the early-20th-century colonial era. Due to their old age, these plants are prone to nematodes as well as infestations by fungi, unwanted weeds, and other potentially harmful organisms. Some agricultural technologies such as bud grafting and side-cleft grafting were introduced in 2006 and 2008, respectively, to increase plants' resistance to nematodes and to combine plants' good traits to rehabilitate and revitalize them. Rehabilitation can be carried out by removal or replacement of existing unproductive trees via side grafting or bud grafting. Side grafting involves utilizing scions from plants known for high yields and quality beans for side grafting to existing unproductive trees. To foster successful grafting and budding, farmers have to use healthy wood with active buds and make sure the bud wood is of the right age and thickness for the rootstock. In addition, grafting should not be done in very hot or very wet seasons.

Farmers are also encouraged to use dead-end trench as the medium of water absorption and containment for plant remains such as pruned leaves or leaf litter. The dead-end trench is around 50 cm $\times$ 30 cm wide and around 30 cm deep. While digging the holes, contact with the coffee plants causes rejuvenation of the hair roots, stimulating their growth. Extension agents encourage both these practices in the district, as they are part of the nationwide government program to boost productivity of coffee and cocoa farming.

Table 12: Training participation rate

	Non-invited respondents	Invited by lottery		Training participation rate
		Participating respondents	Non-participating respondents	
Training in hometown		39 (12.5%)	13 (4.2%)	75%
Training in intra-island		39 (12.5%)	13 (4.2%)	75%
Training in inter-island		42 (13.5%)	10 (3.2%)	81%
Total	156 (50%)	120 (38.5%)	36 (11.5%)	
Grand Total	**312**			

Furthermore, fertilizer use is highly encouraged by extension agents, to maintain general tree health and increase crop production. Organic fertilizer use is highly promoted, as strict regulations exist regarding the levels of chemical substances allowed for coffee and cocoa beans eligible for export to the international market. Farmers are becoming less dependent upon chemical fertilizer as extension services have advocated use of organic fertilizer. The most prevalent organic fertilizers used in the area are made of goat and cow manures as well as green compost.

This study focuses on analyzing the adoption of each technology individually, namely dead-end trench or soil- and water-conservation technique, the grafting method or plant-rehabilitation technique, and the use of both chemical and organic fertilizers.

5.4 DESCRIPTIVE STATISTICS

5.4.1 *Descriptive Statistics of Training Participants*

The baseline survey is conducted in September 2012. In April 2013, I randomly invited 156 farmers to participate in three days training: the first and second day would be the lecture on coffee and cocoa cultivation respectively, and the last day would be pilot farm visit, field trip, and visit to prominent farmers' farmland. Out of 156 invited, 52 farmers are invited to training located in their hometown, 52 farmers are invited to intra-island location, and the rest 52 are invited to inter-island location in the neighboring Java island. On the day of the training, 39 farmers showed up for hometown training, 39 farmers came for intra-island training, and 42 participated in inter-island training, as shown in Table 12.

Table 13 displays the general household characteristics of the invited and uninvited groups to confirm the randomization process. On average, invited farmers have fewer adults in the family. Education, income, and community characteristics do not differ between invited and uninvited farmers, which indicate that the randomization works well. Household heads in the district are generally in their 40s, indicating that majority are young families. Average years of education of household head is 8 years, suggesting that most did not complete their middle school education (junior high school). More than half of the household head are second generation migrants from Java island, even though most of them never visit Java island. Almost all farmers employ labor for agricultural works and possess at least one mobile phone or motorbike. Only around 28 farmers out of 312

Table 13: Descriptive statistics of the invited and uninvited farmers

	All	Invited for training (all)	Invited for training (home-town)	Invited for training (intra-island)	Invited for training (inter-island)	Non-invited for training	Mean difference Invited (all) vs. Non-Invited for training
Household Characteristics							
Age of Household head	45.07 (11.57)	44.05 (11.01)	44.66 (10.86)	42.22 (11.61)	45.30 (10.40)	46.06 (12.04)	-2.01
Years of schooling of household head	8.390 (3.48)	8.240 (3.27)	8.410 (3.58)	8.220 (3.03)	8.000 (3.29)	8.540 (3.69)	-0.29
No. of adult in the family (15-64 years old)	3.000 (1.33)	2.840 (1.23)	2.700 (0.944)	2.670 (1.12)	3.160 (1.51)	3.1600 (1.40)	-0.318**
Log of cultivated farmland	-0.165 (0.75)	-0.177 (0.681)	-0.17 (0.67)	-0.30 (0.687)	-0.05 (0.67)	-0.153 (0.828)	-0.02
No of cattle owned	0.189 (0.713)	0.131 (0.535)	0.02 (0.141)	0.215 (0.701)	0.156 (0.578)	0.245 (0.847)	-0.113
Log of estimated animal value	12.25 (5.31)	12.19 (5.41)	12.35 (5.22)	12.00 (5.81)	12.28 (5.24)	12.31 (6.441)	-0.115
Log of farm income	16.19 (1.28)	16.23 (1.26)	16.17 (1.56)	16.05 (1.15)	16.46 (0.98)	16.16 (1.31)	0.073
Hired labor[1]	0.9700 (0.15)	0.9800 (0.11)	0.96 (0.196)	1.0000 (0.000)	1.0000 (0.000)	0.962 (0.191)	0.024
Native[1]	0.067 (0.251)	0.085 (0.28)	0.137 (0.347)	0.098 (0.30)	0.019 (0.14)	0.050 (0.219)	0.035
Second generation migrant[1]	0.623 (0.485)	0.618 (0.486)	0.6200 (0.48)	0.607 (0.493)	0.627 (0.488)	0.628 (0.484)	-0.010
No. of Mobile Phone	1.500 (1.14)	1.420 (1.05)	1.450 (9.23)	1.25 (0.976)	1.580 (1.21)	1.572 (1.21)	-0.144
No. of Motorbike	1.300 (0.84)	1.350 (0.90)	1.450 (0.91)	1.23 (0.838)	1.390 (0.96)	1.250 (0.78)	0.097
Plot Characteristics							
Distance to farmland[2]	22.09 (46.16)	24.66 (62.01)	20.47 (19.30)	18.47 (20.72)	34.46 (102.12)	19.62 (21.93)	5.04
Community Characteristics							
Walking distance to unpaved road[2]	1.420 (3.56)	1.670 (4.06)	2.050 (5.05)	1.660 (4.05)	1.280 (2.76)	1.180 (3.01)	0.49
Walking distance to paved road[2]	3.370 (7.06)	3.590 (6.97)	3.280 (5.51)	3.090 (6.47)	4.340 (8.59)	3.160 (7.15)	0.43
Total no of observation	312	156	52	52	52	156	

[1] *(=1 if Yes)*
[2] *(in minutes)*
*Standard deviations are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*
Data is taken in the period of 2012 (during the baseline survey).

own cattle.

Meanwhile, Table 14 shows the characteristics of invited farmers who joined the training and who didn't participate in the training. Major difference between this group only lies on the walking distance to farmland (in minutes), with those who didn't come to the training have approximately 30 minutes longer of walking distance compared to those who joined the training.

Two professional trainers from the Indonesian Coffee and Cocoa Research Institute (ICCRI) were invited to provide lectures during the first two days. The trainers provided the training materials. The trainers and training-program materials were identical at each location. I ensured that all training locations offered similar environments. The in-class training materials for coffee and cocoa on the first and second days consisted of basic cultivation training, such as (1) ways to select high-yield varieties, plant the seeds correctly, and maintain them; (2) information on shade trees and crop management; (3) con-

Table 14: Descriptive statistics of the participating vs non-participating invited farmers

	All Invited	Invited and Participated	Invited But Didn't Participate	Mean Difference
Household Characteristics				
Age of Household head	44.05 (11.01)	43.87 (10.49)	44.68 (12.86)	-0.811
Years of schooling of household head	8.24 (3.27)	8.18 (3.33)	8.468 (3.06)	-0.282
No. of adult in the family (15-64 years old)	2.84 (1.23)	2.787 (1.198)	3.030 (1.355)	-0.243
Log of cultivated farmland	-0.177 (0.681)	-0.203 (0.701)	-0.083 (0.601)	0.120
Log of estimated animal value	12.19 (5.415)	12.041 (5.495)	12.76 (5.155)	-0.724
Log of farm income	16.23 (1.263)	16.20 (1.137)	16.34 (1.650)	-0.138
Hired labor[1]	3 (2.19)	2.882 (2.151)	3.424 (2.332)	-0.5418
Native[1]	0.0855 (0.2805)	0.0840 (0.2786)	0.0909 (0.2919)	-0.006
Second generation migrant[1]	0.618 (0.4873)	0.6302 (0.4847)	0.575 (0.5018)	0.0544
No. of Mobile Phone	1.427 (1.052)	1.436 (1.022)	1.393 (1.170)	0.0430
No. of Motorbike	1.355 (0.901)	1.327 (0.844)	1.454 (1.092)	-0.1268
Plot Characteristics				
Distance to farmland[2]	24.669 (62.161)	18.36 (18.328)	49.241 (131.63)	-30.87**
Community Characteristics				
Walking distance to unpaved road[2]	1.678 (4.061)	1.671 (3.624)	1.702 (5.423)	-0.030
Walking distance to paved road[2]	3.594 (6.978)	3.908 (7.538)	2.4612 (4.306)	1.447
Total no of observation	156	120	36	

[1] *(=1 if Yes)*
[2] *(in minutes)*
*Standard deviations are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*
Data is taken in the period of 2012 (during the baseline survey).

cepts of agricultural technology such as side-cleft and bud grafting or plant rehabilitation technique (as shown in Figure 11), and dead-end trench or soil- and water-conservation technique (as indicated in Figure 12); and (4) information on fertilizer, including ways to procure organic fertilizers from livestock and to make compost (as depicted in Figure 13). The third day primarily consisted of a pilot-farm visit. At the pilot farm the trainers showed the correct ways to do both side-cleft and bud grafting, as well as giving practical information on how to maintain a plantation using the situation and conditions in the pilot farm as an example. The farmers could also observe many ways to maintain their farmland by making dead-end trench, as well as learn how to make organic fertilizer using animal manure and compost. For the case of pilot farm visit in intra- (South Lampung district) and inter-island-located training (Garut and Ciamis district), selected influential farmers in the area were invited by the district government to facilitate discussion and networking with training participants who came from Tanggamus district. These informal introduction enable farmers to exchange mobile numbers and allow future correspondence and cooperation.

5.4.2 *Descriptive Statistics of Agricultural Technologies and Social Network*

Post-evaluation surveys were conducted twice, first in September 2013 then in September 2014. In total, I managed to obtain a panel dataset covering three years. Table 15 shows whether adoption behavior changed due to training participation on average. In general, all respondents reported a significant increase in the diffusion and adoption of dead-end trench by 4.2% and 6.9% respectively, as well as a significant decline (17.2%) in the usage of chemical fertilizer. The upsurges are attributed to the significant increase in knowledge and adoption of new techniques by training participants, and not so much by the

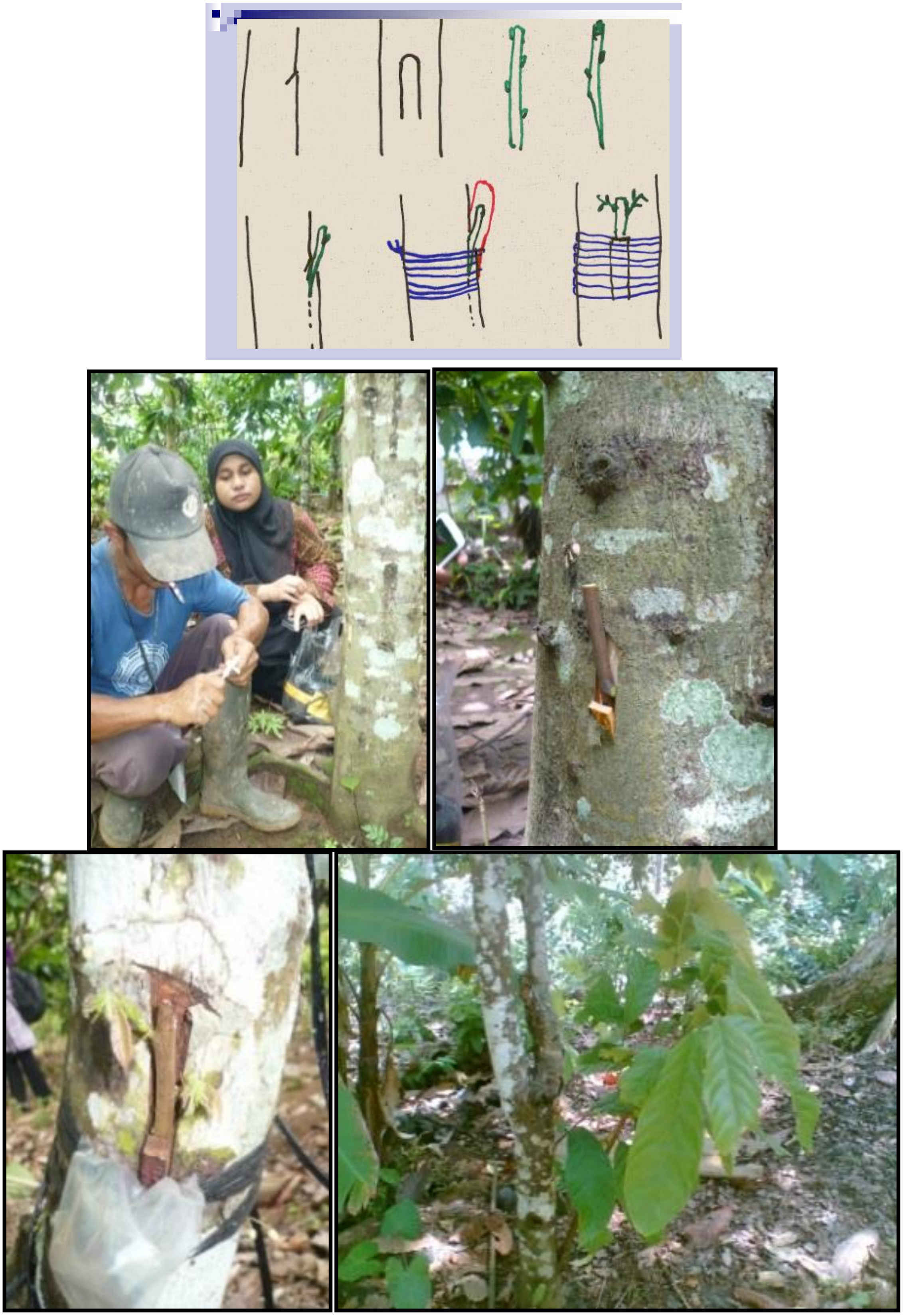

Figure 11: Grafting methods

Figure 12: Dead-end trench (Rorak) methods

Figure 13: Techniques of making compost

non-participants. After the training period, diffusion and adoption of technologies are stronger on training participants compared to non-training participants.

Lastly, Table 16 illustrates various social network variables. After the training, hometown and intra-island training participants talked less with their sources of information who did not attend training and who belonged to a different training group, respectively. In contrast, inter-island training participants met with their agricultural-advice-network sources significantly more frequently.

5.5 EMPIRICAL METHODOLOGY

5.5.1 *Estimation Strategy*

This study attempts to support the regional government's effort to promote the commodity revitalization program by increasing farmers' awareness of grafting and dead-end trench techniques and to propel adoption of those techniques. In the estimation strategy, I distinguish between adoption into diffusion of knowledge on the one hand, and implementation of knowledge, which was the framework first introduced by Todo et al. (2011). Diffusion is defined as "the process in which an innovation is communicated through certain channels over time among the members of a social system" (Rogers and Sheppard, 2010), and is a prerequisite of technology adoption. Therefore, the dependent variables are (1) knowing the technology and (2) adopting technology predicated on the condition

Table 15: Descriptive statistics of the technology diffusion and adoption prior to and after the training

Variables	Before Training	After Training	Difference (all farmers)	Before Training	After Training	Difference (training participant)	Before Training	After Training	Difference (non-training participant)	Before Training	After Training
	All farmers	All farmers		Training participant	Training participant		Non-Training participant	Non-Training participant		Difference (Training Participant vs Non-training Participant)	Difference (Training Participant vs Non-training Participant)
Knowing Water Conservation Technique[1]	0.878 (0.327)	0.920 (0.270)	0.042**	0.871 (0.335)	0.948 (0.222)	0.076**	0.882 (0.322)	0.903 (0.295)	0.020	-0.011	0.044**
Knowing Grafting[1]	0.897 (0.304)	0.891 (0.312)	-0.0064	0.915 (0.025)	0.941 (0.235)	0.025	0.885 (0.023)	0.859 (0.348)	-0.026	0.0305	0.081***
Adopting Soil and Water Conservation Technique[1]	0.75 (0.429)	0.826 (0.379)	0.069**	0.747 (0.436)	0.857 (0.350)	0.109**	0.762 (0.426)	0.805 (0.396)	0.033	-0.014	0.052
Adopting Grafting[1]	0.845 (0.361)	0.827 (0.377)	-0.017	0.857 (0.351)	0.865 (0.342)	0.0084	0.838 (0.368)	0.804 (0.396)	-0.043	0.018	0.060*
Current usage of chemical fertilizer[1]	0.733 (0.025)	0.561 (0.496)	-0.172***	0.680 (0.468)	0.529 (0.500)	-0.151***	0.765 (0.424)	0.580 (0.494)	-0.184***	-0.084	-0.051
Current usage of organic fertilizer[1]	0.720 (0.449)	0.734 (0.441)	0.0144	0.739 (0.440)	0.768 (0.422)	0.0294	0.708 (0.455)	0.713 (0.452)	0.005	0.031	0.055

[1] *(=1 if Yes)*

*Standard deviations are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*

Table 16: Summary statistics of farmers' network

	All Farmers (Participants and Non-participants)			All Participants			Participants Attended Hometown Training			Participants Attended Intra-Island Training			Participants Attended Inter-Island Training			Non-participants		
	Before Training	After Training	Diff	Before Training	After Training	Diff	Before Training	After Training	Diff	Before Training	After Training	Diff	Before Training	After Training	Diff	Before Training	After Training	Diff
Number of source of agricultural information who went to the same training location				0.563 (0.860)	0.441 (0.67)	-0.12	0.512 (0.913)	0.358 (0.580)	-0.153	0.605 (0.886)	0.473 (0.60)	-0.131	0.571 (0.800)	0.488 (0.813)	-0.08			
Number of agricultural information source who went to the different training location				0.890 (0.95)	0.760 (1.04)	-0.13	0.948 (1.122)	1 (1.319)	0.051	0.973 (0.884)	0.684 (0.79)	-0.29^{*}	0.761 (0.849)	0.607 (0.918)	-0.154			
Number of agricultural information source who did not go to the training[1]				3.74 (3.13)	3.327 (2.35)	-0.42	4.051 (3.24)	3.050 (2.14)	-1^{**}	3.63 (2.79)	3.47 (2.49)	-0.157	3.57 (3.351)	3.452 (2.421)	-0.119			
Meet frequently with agricultural information source[2]	0.138 (0.34)	0.170 (0.38)	0.032	0.142 (0.35)	0.189 (0.39)	0.046	0.205 (0.409)	0.192 (0.396)	0.013	0.157 (0.369)	0.171 (0.38)	0.013	0.071 (0.260)	0.202 (0.404)	0.13^{*}	0.135 (0.34)	0.158 (0.36)	0.023
Know extension agent and have frequent contact[3,4]	0.225 (0.42)	0.202 (0.40)	-0.022	0.210 (0.41)	0.260 (0.44)	0.050	0.256 (0.442)	0.256 (0.442)	0	0.210 (0.413)	0.210 (0.41)	0	0.166 (0.377)	0.3095 (0.467)	0.142^{*}	0.234 (0.42)	0.166 (0.37)	-0.07^{**}
Know professional trainers[3,4]	0.00 (0.000)	0.1860 (0.3890)	0.186^{**}	0.000 (0.000)	0.4150 (0.4940)	0.415^{***}	0.000 (0.000)	0.282 (0.455)	0.28^{***}	0.000 (0.000)	0.54 (0.505)	0.54^{**}	0.00 (0.00)	0.428 (0.500)	0.42^{***}	0.00 (0.000)	0.038 (0.192)	0.038^{***}
Know bridging ties: farmers who lived in intra-island (South Lampung district)[3,4]	0.000 (0.000)	0.059 (0.237)	0.059^{***}	0.000 (0.000)	0.152 (0.361)	0.152^{***}	0.000 (0.000)	0.000 (0.000)	0	0.000 (0.000)	0.459 (0.505)	0.459^{***}	0.000 (0.000)	0.02 (0.154)	0.02	0.00 (0.000)	0.000 (0.000)	0.00
Know bridging ties: farmers who lived in inter-island (Garut or Ciamis district)[3,4]	0.000 (0.000)	0.1670 (0.683)	0.167^{***}	0.000 (0.000)	0.344 (0.976)	0.344^{***}	0.000 (0.000)	0.300 (1.160)	0.302	0.000 (0.000)	0.142 (0.505)	0.142	0.000 (0.000)	0.531 (0.018)	0.531^{***}	0.000 (0.000)	0.052 (0.337)	0.052^{**}
Out-degree Centrality[5]	0.303 (0.195)	0.232 (0.157)	-0.07^{***}	0.295 (0.203)	0.241 (0.170)	-0.05^{**}	0.286 (0.218)	0.253 (0.198)	0.032	0.297 (0.148)	0.218 (0.136)	-0.07^{**}	0.303 (0.236)	0.252 (0.170)	0.05	0.309 (0.190)	0.226 (0.146)	-0.08^{***}
Out-closeness Centrality[5]	0.55 (0.117)	0.580 (1.02)	0.025	0.541 (0.126)	0.550 (0.151)	0.003	0.540 (0.131)	0.602 (0.190)	0.005	0.537 (0.098)	0.526 (0.144)	-0.0107	0.557 (0.147)	0.521 (0.092)	-0.036	0.560 (0.1119)	0.600 (1.310)	0.0400
Betweenness Centrality[5]	0.061 (0.088)	0.068 (0.107)	0.08	0.062 (0.097)	0.079 (0.125)	0.017	0.067 (0.136)	0.084 (0.144)	0.0167	0.062 (0.066)	0.071 (0.101)	0.005	0.05 (0.075)	0.083 (0.127)	0.031	0.059 (0.821)	0.0612 (0.0931)	0.0013
Total no of observation	312	624		120	240		39	78		39	78		42	84		192	384	

[1] *(May or may not be farmers)*
[2] *(Meet at least once every 2 weeks, = 1 if Yes)*
[3] *(Have contact at least once every 2 weeks, = 1 if Yes)*
[4] *(Only available in 2012 and 2013)*
[5] *(Only applicable for those who listed farmers group members as agricultural informants)*
*Standard deviations are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*

of knowing it. "Knowing" means having knowledge of how to implement the techniques, while "adopting" means having successfully implemented the technologies in one's own farmland. Both are constructed as dummy variables. Delving deeper, this study distinguishes between the impact of the training in general, and the impact of location heterogeneity.

As is always the case with impact-evaluation studies, participation in training is likely to cause a self-selection bias. Although I randomly invited farmers to each training locale, and Table 12 shows that on average no differences exist between invited and non-invited farmers, the decision of whether to participate in training is ultimately the farmer's choice and thus the model may suffer from endogeneity in this variable. To examine the pure effect of training participation, I employ the Local Average Treatment Effect (LATE) model and instrument the participation status with random invitation status. Thus, I report the treatment effect on the treated (TOT) rather than the intention-to-treat (ITT) effects. The results of ITT, which are very similar to the TOT estimation I present here, are available upon request.

Among the models tested are the Fixed-Effect and Random-Effects instrumental variable models. However, due to the Hausman-test result in most of the regression result, which supported the validity of employing the Random-Effects model, in addition to the ability to fit more into the data and the analysis, I decided to employ the Random-Effects-IV model as follows:

1. Effects of Training on Agricultural Technology Diffusion

$$\mathsf{KnowTECH}^{j}_{i,t} = \alpha + \beta_1 \mathsf{Training}_{i,t} * \mathsf{Post2013} + \beta_2 \mathsf{Training}_{i,t} * \mathsf{Post2013} * \mathsf{Location}_l + \beta_3 \mathsf{Post2013} + \beta_4 \mathsf{Training}_{i,t} + \beta_5 \mathsf{Training}_{i,t} * \mathsf{Location}_l + u_i + w_{i,t}$$

2. Effects of Training on Agricultural Technology Adoption on Condition of Knowing it

$$\mathsf{AdoptTECH}^{j}_{i,t} = \alpha + \beta_1 \mathsf{Training}_{i,t} * \mathsf{Post2013} + \beta_2 \mathsf{Training}_{i,t} * \mathsf{Post2013} * \mathsf{Location}_l + \beta_3 \mathsf{Post2013} + \beta_4 \mathsf{Training}_{i,t} + \beta_5 \mathsf{Training}_{i,t} * \mathsf{Location}_l + u_i + w_{i,t} \quad \text{if } \mathsf{Diffusion}_{i,t} = 1$$

where j is the measured crop technologies (j = dead-end trench, grafting methods, and organic and chemical fertilizer), and i is the household head in year t. In Estimation 1, the dependent variable is technology diffusion, or the dummy variable of "Knowing" the technology for grafting and dead-end trench methods. The independent variable is the interaction term between the training participation dummy and the year of post-2013, which aims to reveal the effects of training upon adoption, and the interaction term of the training participation dummy, the year of post-2013 and location l dummy (hometown, intra-island, and inter-island), whose purpose is to examine the impact of location heterogeneity. Estimation 1 is also being used to test usage of chemical and organic fertilizer in the last harvest. I do not check knowledge of fertilizers prior to their usage as they are already common in the area.

In Estimation 2, the dependent variable is technology adoption, or the dummy variable of "Adopting" the technology predicated on the condition of "knowing" it. Adopting means having ever implemented the techniques in their farmland, depending upon the condition of knowing them previously.

To examine the factors driving the difference in technology adoption, I analyze how farmers' social networks have changed due to training and how this network contributes to the diffusion and adoption of agricultural technologies. For this I have the following model:

3. Effects of Training on Various Network Variables

$$Network_{i,t} = \alpha + \beta_1 Training_{i,t} * Post2013 + \beta_2 Training_{i,t} * Post2013 * Location_l + \beta_3 Post2013 + \beta_4 Training_{i,t} + \beta_5 Training_{i,t} * Location_l + u_i + w_{i,t}$$

In Estimation 3, the dependent variable is various social network variables. Sometimes, farmers like to discuss farming with other people, and these variables are employed to capture farmers' personal networks. To report on these variables, farmers have to recall the names of people outside their household from whom they seek advice, can learn from, or from whom they can generally obtain useful information about farming practices, particularly about coffee and/or cocoa. In this study, I am trying to investigate the impact of the training upon four personal-network variables, namely:

(AN1) Training participants' agricultural advice network upon returning from the training
In this case, I am examining the possibility of whether training participants increase their communication intensity with fellow farmers who went to the same training group, a different training group, or farmers who did not go to the training at all.

(AN2) Training participants' personal network with bridging ties upon returning from the training
Training participants are exposed to bridging ties, or people outside their community who may help connecting farmers to 'outside world' and transferring information to farmers' local neighborhood. Professional trainers and influential contact farmers in the intra- and inter-island training location can possibly serve as bridging ties.
Professional trainers were introduced to the participants during the course of the training. In the end of the training program, trainers gave their mobile numbers so farmers can access them personally if they need help with their farming practices. In addition, influential contact farmers were introduced to the farmers who undertook training in intra-island and inter-island training locations during the pilot farm visit. During the visit, participants are able to exchange mobile number with these contact farmers, enabling future correspondence and cooperation to take place after the training program ends.
These variables examine whether farmers have enlarged their network to reach informants outside their community, whether they "know" some bridging ties as the source of advice and maintain communication with them. "Knowing" has to be mutual. If a farmer testifies that they know a person, then that person should also know that farmer. "Knowing" also means that the farmer can directly contact the person when needed. Data on networking with bridging ties are only available in 2012 and 2013.

(AN3) Farmers' meeting frequency with their agricultural informants
Besides investigating the effect of the training upon trained farmers' networks, I am also looking at whether training increased the frequency of meetings with their sources of

agricultural information in general.

(AN4) Farmers' network ties with agriculture specialists
In addition to peer networks, I am also trying to examine farmers' frequency of communication with agricultural experts, namely extension agents. Extension agents are chosen because they are accessible and regarded as more advanced sources of information than fellow farmers. In addition, extension agents possess more knowledge and often advise farmers on good practice. However, data on networking with experts are only available for 2012 and 2013.

4. Effects of Network Position on Information Diffusion and Technology Adoption

Previously, Chapter 4 concludes that one's position in their locale matters for learning outcomes, as farmers who occupy the central position in their network tend to have better information processing ability during institutionalized training. This part intends to see whether such effects are present in the diffusion and adoption of agricultural technology.
Network position is measured based on information regarding advice network from inside the farmers group (peers advice network). In group-level, farmers testify whom they obtained information from or talked to regarding agricultural practices, so the direction is outward. Network position can help explain the individual level of importance and influence within the group. The information needed to construct the centrality is the identifier of the individual who initiated the advice seeking (source) and the identifier of the individual who serves as the target of the advice seeking (target) from each farmers group that become the unit of the study. Three kinds of centrality measures are computed, namely degree-centrality, closeness-centrality and betweenness centrality (see Section 4.5 for reference).
Some limitations persist when analyzing network positions in panel analysis: farmers have to list farmers group members as agricultural advice network in three consecutive years. If farmers did not mention any group members in some of the years, then the centrality measures during those years cannot be obtained. When this happens, all the three years observations of those farmers cannot be taken into account in the panel analysis.
Network position is likely to be correlated with other individual-specific unobserved variables that positively impact technology diffusion and adoption. Therefore, the between effect (and the estimate from the random intercept model, which is a weighted average of the between and within estimates, may overestimate the effect of network position (Wooldridge, 2010). In such cases, a correlated random-effects model becomes an alternative because of it can estimate the within effects in random effect models (Allison, 2009; Schunck, 2013; Mundlak, 1978). I perform the correlated random effects model as follow:

$$\mathrm{KnowTECH}^{j}_{i,t} = \alpha + \beta_1 \mathrm{Centrality} * \mathrm{Training}_{i,t} * \mathrm{Post2013} + \beta_2 \mathrm{Centrality} + \beta_3 \mathrm{Training}_{i,t} * \mathrm{Post2013} + \beta_4 \mathrm{Post2013} + \beta_5 \mathrm{Training}_{i,t} + \pi \overline{x_i} + u_i + w_{i,t} \text{ if Agricultural Advice Network > 0}$$

Estimation 4 examines the effects of training participants' network position in their local neighborhood on the diffusion and adoption of technology post training using the correlated random effects (CRE) model. The CRE model relaxes the assumption of zero correlation between the level 2 (for example, subject) error and the level 1 (for example,

occassions) variables by adding the cluster mean of $x_{i,t}$ which picks up any correlation between this variable and the level 2 error (Mundlak, 1978; Wooldridge, 2010).
Therefore, in this estimation, the variable of interest is $Centrality * Training_{i,t} * Post2013$. Effects of centrality measures in general on the diffusion and adoption process are also represented in $Centrality$ variable.

5. Information Spillover from Training Participants to Non-training participants

$KnowTECH^{j}_{i,t} = \alpha + \beta_1 NetworkwithTrainingParticipants * Post2013 + \beta_2 NetworkwithTrainingParticipants + \beta_3 Training_{i,t} * Post2013 + \beta_4 Training_{i,t} * Post2013 * Location_l + \beta_5 Post2013 + \beta_6 Training_{i,t} + \beta_7 Training_{i,t} * Location_l + u_i + w_{i,t}$ if Non-training Participants = 1

In Estimation 5, I particularly examine the spillover of training participants on technology diffusion and adoption to non-participants post training. For this estimation, the main variable of interest is network with training participants after the training or $NetworkwithTrainingParticipants * Post2013$, which are constructed as farmers' agricultural advice network who attended the training. Social network variable may possibly be endogenous because those who adopt may be influential thus already having more networks to begin with. Furthermore, this variable is treated as an independent variable in further analysis. To deal with endogeneity, social network with training participants is instrumented with social network with farmers who are invited to the training, as invitation to attend the training is randomized.

5.6 RESULTS

5.6.1 *Effects of Training on Agricultural Technology Diffusion and Adoption*

The influence of training in general upon the diffusion and adoption of all technologies individually is shown in Table 17. Column 2 shows that the probability of knowing grafting methods increased by 9.9 percentage points for training participants. Grafting is a more complicated technique, as the joining has to be done before the rainy season. The grafted point is then bound with tape and has to be checked regularly to prevent dehydration and germs. Training participants in general seem to have significantly benefited from the training as they managed to obtain accurate knowledge of grafting. However, I found that the financial access may have contributed to the adoption of organic fertilizer and grafting technique. Number of motorbike seems to have been associated with adoption of grafting technique as well as organic fertilizer, while availability of mobile phone in the households may have been correlated positively with the adoption of the former. These may indicate that access to information from outside the community may have been important in explaining the cause of grafting adoption, as mobile phone and motorcycle may serve as a proxy for facilitating access to external sources.

The usage of chemical fertilizer also significantly diminished in the second-year post-training by 25.8 percentage points, even though training did not contribute to this effect. The effect of the training, however, does not seem to help in improving diffusion and adoption of the remaining techniques.

Table 17: The influence of training on technology adoption

Variables	Knowing soil and water conservation technique	Knowing grafting methods	Adopting soil and water conservation technique on condition of knowing it	Adopting grafting method on condition of knowing it	Currently using organic fertilizer	Currently using chemical fertilizer
	(1)	(2)	(3)	(4)	(5)	(6)
Training*Post 2013	0.0741	0.0989**	0.0275	-0.0332	0.00133	-0.00854
	(0.0478)	(0.0488)	(0.0540)	(0.0421)	(0.0708)	(0.0739)
Training (1 = Yes)	-0.0189	-0.01500	0.00274	0.0168	0.0735	-0.0562
	(0.0426)	(0.0447)	(0.0504)	(0.0407)	(0.0635)	(0.0687)
Year of 2013	0.0237	-0.0485*	0.0275	-0.00860	0.0179	-0.0778*
	(0.0287)	(0.0290)	(0.0323)	(0.0259)	(0.0421)	(0.0439)
Year of 2014	-0.00196	-0.0539*	0.0275	0.0182	-0.0171	-0.258***
	(0.0290)	(0.0291)	(0.0330)	(0.0261)	(0.0422)	(0.0441)
ROSCA (=1 if Yes)	0.0733	0.144*	-0.0418	0.0521	0.257**	-0.00573
	(0.0797)	(0.0768)	(0.0992)	(0.0852)	(0.113)	(0.127)
No of Motorcycle owned	0.0147	0.0440***	-0.00821	-0.000456	0.0598***	0.0156
	(0.0128)	(0.0121)	(0.0147)	(0.0116)	(0.0176)	(0.0192)
Mobile Phone Dummy	-0.0138	0.106***	0.0543	0.00168	0.0414	0.0226
	(0.0304)	(0.0293)	(0.0350)	(0.0286)	(0.0428)	(0.0459)
Living Nearby Extension Workers	0.00291	0.0248	0.0666**	0.0289	-0.0600	0.0457
	(0.0264)	(0.0267)	(0.0303)	(0.0253)	(0.0390)	(0.0423)
Constant	0.805***	0.612***	0.850***	0.859***	0.342***	0.711***
	(0.0848)	(0.0812)	(0.105)	(0.0891)	(0.119)	(0.133)
Observations	898	933	800	833	933	933
Number of hhid	311	311	306	309	311	311
P-value of Hausman Test	0.0000	0.0685	0.0237	0.2371	0.6758	0.5809

*Estimation is based on Random-Effects Instrumental Variable models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result.*

Table 18 displays the effect of location heterogeneity upon technology diffusion and adoption. Column (3) indicates a significant upsurge of adoption of dead-end trench by farmers attending the inter-island training location by 18.5 percentage points. I also find that farmers who trained in the inter-island location may have stronger prior knowledge of dead-end trench, as shown in Column 1. In addition, column 1 shows that training increased the participating farmers' knowledge of dead-end trench by 15.1 percentage points relative to non-participants. These indicate that the inter-island training helped participants reach the next stage of actually implementing the knowledge they have by adopting the practices to some extent.

For grafting techniques and fertilizer usage, I did not find any significant factors. I can offer several reasons why adoption of dead-end trench is stronger than that of the grafting methods. First, grafting is more technical and complicated, as it must be done in a very specific time-frame, while the dead-end trench method is not time-specific. Second, grafting is more time consuming, as farmers have to maintain the joint plant, which is prone to attracting insects and germs. On the usage of organic fertilizer, only 28 out of 312 farmers own cattle for procuring animal manures. Extension agents also reported that farmers tend to buy organic fertilizer than compose it, making both the usage remained low even after the training taught them how to make compost.

This section shows that training, regardless of location, does improve knowledge, indicating that the third hypothesis may not be supported. When training materials and environment are kept identical throughout the programs, knowledge obtained does not vary much. This study also provides evidence that formal training helped

Table 18: Locational heterogeneity in the training impact on technology adoption

Variables	Knowing soil and water conservation technique	Knowing grafting methods	Adopting soil and water conservation technique on condition of knowing it	Adopting grafting method on condition of knowing it	Currently using organic fertilizer	Currently using chemical fertilizer
	(1)	(2)	(3)	(4)	(5)	(6)
Training*post 2013*intra-island	-0.116	-0.0380	0.0655	0.0940	-0.0942	-0.0732
	(0.0818)	(0.0726)	(0.0970)	(0.0743)	(0.121)	(0.131)
Training*post 2013*inter-island	-0.114	-0.0197	0.185**	0.0822	0.0167	-0.0873
	(0.0787)	(0.0687)	(0.0923)	(0.0714)	(0.115)	(0.124)
Training*post 2013	0.151**	0.0787	-0.0608	-0.0915	-0.000689	0.0297
	(0.0654)	(0.0576)	(0.0769)	(0.0602)	(0.0963)	(0.104)
Training (1 = Yes)	-0.113*	-0.0179	0.00975	0.0412	0.00858	-0.0983
	(0.0629)	(0.0655)	(0.0718)	(0.0591)	(0.0929)	(0.100)
Training intra-island (1 = Yes)	0.121	0.0648	0.00413	-0.0618	0.1280	0.0176
	(0.0785)	(0.0824)	(0.0903)	(0.0731)	(0.1170)	(0.126)
Training inter-island (1 = Yes)	0.162**	0.000212	-0.0182	-0.0265	0.0636	0.1560
	(0.0760)	(0.0785)	(0.0864)	(0.0706)	(0.111)	(0.1200)
Year of 2013	0.0239	0.00227	0.0264	-0.00815	0.0545	-0.0500
	(0.0280)	(0.0247)	(0.0330)	(0.0261)	(0.0411)	(0.0442)
Year of 2014	-0.00296	0.0138	0.0241	0.0152	0.0264	-0.227***
	(0.0283)	(0.0249)	(0.0337)	(0.0263)	(0.0414)	(0.0446)
ROSCA (= 1 if Yes)	0.0926	0.1300	-0.0528	0.1110	0.1440	-0.1320
	(0.106)	(0.1210)	(0.117)	(0.1020)	(0.1560)	(0.1680)
Living Nearby Extension Official	0.00743	0.0511*	0.0585*	0.0264	-0.0646	0.0372
	(0.0272)	(0.0265)	(0.0304)	(0.0254)	(0.0399)	(0.0430)
No of Motorcycle	0.00846	0.0171	-0.00453	-0.00143	0.0411**	-0.00126
	(0.0128)	(0.0118)	(0.0143)	(0.0112)	(0.0175)	(0.0189)
Cultivated Farmland (in Ha)	-0.00331**	0.00208	0.0145	0.000715	-0.00300	0.000911
	(0.00141)	(0.00131)	(0.0135)	(0.00129)	(0.00209)	(0.00225)
Constant	0.807***	0.709***	0.891***	0.822***	0.541***	0.800***
	(0.116)	(0.133)	(0.130)	(0.113)	(0.171)	(0.184)
Observations	886	899	789	823	899	899
Number of hhid	308	308	302	306	308	308
P-value of Hausman Test	0.5200	0.6895	0.056	0.000	0.8253	0.8822

*Estimation is based on Random-Effects Instrumental Variable models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result. Dummy of hometown is instrumented by invitation for training in hometown (Tanggamus). Dummy of intra-island is instrumented by invitation for intra-island training (Kalianda, South Lampung). Dummy of inter-island is instrumented by invitation for inter-island training (Garut and Ciamis, West Java).*

to advance farmers' knowledge regarding plant-rehabilitation and conservation techniques.

However, only training held in the most remote place is found to spur the adoption of agricultural technology, suggesting the second hypothesis is supported. While training in general is revealed to have increased the probability of knowing the technology, only inter-island-located training is found to produce higher chance to propel adoption. Several causes may explain the adoption, that participants trained in inter-island have in fact obtained something different from the training, namely the experiences or the social network during the training. Inter-island training participants may get motivated by the recreational features in the more developed and advanced island, thus coming back to their hometown with more open-mind. This changes in attitudes may help propel adoption. Alternatively, they may get more inclination to adopt from their social network. I examine further why being trained at an inter-island location has led farmers to adopt the knowledge, by investigating the changes in their social networks in depth in the next section.

5.6.2 *Effects of Training upon Social Network Variables*

The effect of training locations on various network ties is shown in Table 19. Although no significant effect of the training exists in terms of strengthening the bonding among fellow participants from the same training group or from the different training groups, I find that the number of contacts who did not go to training at all increased by 1 person for the inter-island training participants after training. Though the link is non-directional, inter-island training participants are found to have more contacts with non-training participants.

Table 20 examines the effects of training on the depth of social networks by analyzing agricultural information sources, particularly among those who have frequent contact (at least once every 2 weeks). Column 1 and 2 indicate that inter-island training participants are more likely to have frequent meeting with their agricultural advisors by 17.9 and 24.2 percentage points amongst all farmers and amongst participants only, respectively. Column 3 suggests that farmers who went on the inter-island training significantly increased the intensity of their communication with experts (extension workers) by 31.4 percentage points. These evidences suggest that farmers who attended training at a distant location increased their communication intensity with their agricultural information sources compared to before training, and this increased communication may have triggered their changed adoption behavior after training.

Furthermore, the possibility of training participants to enlarge their networks is explored in Table 21. Training participants are found to maintain communication with professional trainers they met during the training program. For those who trained at remote-location (intra- and inter-island), they also seemed to sustain ties with the prominent farmers that they meet during the pilot farm visit in the respective training location.

Further analysis on various network variables pinpoint that inter-island-trained participants obtained the strongest social network post-training, thus supporting the fourth hypothesis. Many network ties, both amongst peers and with experts have strong inclination to stimulate technology adoption. Not only inter-island trained participants increased their network intensity with their peers, they also seem to have "es-

Table 19: Effect of training on the size of social networks

Variables	Number of agricultural information source who went to the same training location	Number of agricultural information source who went to the different training location	Number of agricultural information source who did not go to the training[1]
	(1)	(2)	(3)
Training*Year 2013*intra-island	0.0506	-0.286	0.607
	(0.214)	(0.259)	(0.766)
Training*Year 2013*inter-island	0.172	-0.104	0.377
	(0.209)	(0.253)	(0.748)
Training*Year 2014*intra-island	-0.00607	-0.395	1.078
	(0.214)	(0.259)	(0.766)
Training*Year 2014*inter-island	-0.0311	-0.308	1.385*
	(0.209)	(0.253)	(0.748)
Training intra-island (1 = Yes)	0.0924	0.0250	-0.420
	(0.169)	(0.229)	(0.586)
Training inter-island (1 = Yes)	0.0586	-0.187	-0.480
	(0.165)	(0.224)	(0.572)
Year of 2013	-0.0769	0.128	0.0513
	(0.150)	(0.182)	(0.538)
Year of 2014	-0.231	-0.0256	-2.051***
	(0.150)	(0.182)	(0.538)
Constant	0.513***	0.949***	4.051***
	(0.119)	(0.161)	(0.412)
Observations	357	357	357
Number of hhid	119	119	119
P-value of Hausman test	0.0000	0.0000	1.0000

[1] *(May or may not be farmers)*

*Estimation is based on Random-Effects Instrumental Variable models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result. Dummy of hometown is instrumented by invitation for training in hometown (Tanggamus). Dummy of intra-island is instrumented by invitation for intra-island training (Kalianda, South Lampung). Dummy of inter-island is instrumented by invitation for inter-island training (Garut and Ciamis, West Java).*

Table 20: Effect of training on the depth of social networks

Variables	Having frequent contact with agricultural information source[1]		Knowing extension agent and having frequent contact[2,3]
	All farmers	Only farmers who went to the training	All farmers
	(1)	(2)	(3)
Training*Year 2013*intra-island	0.0930	0.130	0.159
	(0.105)	(0.119)	(0.141)
Training*Year 2013*inter-island	0.179*	0.242**	0.314**
	(0.0947)	(0.116)	(0.135)
Training*Year 2014*intra-island	-0.000630	-0.0783	
	(0.105)	(0.119)	
Training*Year 2014*inter-island	0.142	0.0458	
	(0.0947)	(0.116)	
Training intra-island (1 = Yes)	-0.0540	-0.0472	-0.162
	(0.0768)	(0.0863)	(0.107)
Training inter-island (1 = Yes)	-0.0965	-0.134	-0.155
	(0.0695)	(0.0842)	(0.102)
Year of 2013	0.0287	-0.0513	-0.0692
	(0.0345)	(0.0834)	(0.0429)
Year of 2014	-0.0191	0.0256	
	(0.0345)	(0.0834)	
Training*Year of 2013			-0.0395
			(0.113)
Training (1 = Yes)			0.0863
			(0.0855)
Constant	0.158***	0.205***	0.233***
	(0.0253)	(0.0606)	(0.0326)
Observations	933	357	622
Number of hhid	311	119	311
P-value of Hausman test	0.0000	0.0000	0.000

[1] *(Meet at least once every 2 weeks, = 1 if Yes)*
[2] *(Have contact at least once every 2 weeks, = 1 if Yes)*
[3] *(Only available in 2012 and 2013)*

*Estimation is based on Random-Effects Instrumental Variable models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result. Dummy of hometown is instrumented by invitation for training in hometown (Tanggamus). Dummy of intra-island is instrumented by invitation for intra-island training (Kalianda, South Lampung). Dummy of inter-island is instrumented by invitation for inter-island training (Garut and Ciamis, West Java).*

Table 21: Effects of training on the size of bridging ties

Variables	All Farmers						Training Participants					
	Knowing prominent trainers from ICCRI		Knowing prominent farmers in inter-island training location		Knowing prominent farmers in intra-island training location		Knowing prominent trainers from ICCRI		Knowing prominent farmers in inter-island training location		Knowing prominent trainers in intra-island training location	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Training*Post 2013	0.391***	0.241***	0.0876***	-0.0165	0.153***	-0.0000	0.415***	0.282***	0.0957***	-0.0000	0.153***	
	(0.0496)	(0.0697)	(0.0302)	(0.0413)	(0.0325)	(0.0380)	(0.0454)	(0.0780)	(0.0271)	(0.0449)	(0.0331)	
Training (1 = Yes)	0.0000	0.0000	-0.0000	0.0000	0.0000	0.0000	0.0000	-0.0000	0.0000	-0.0000	0.0000	0.0000
	(0.0350)	(0.0495)	(0.0212)	(0.0293)	(0.0230)	(0.0270)	(0.0320)	(0.0551)	(0.0190)	(0.0317)	(0.0234)	(0.0336)
Training*Post 2013*Intra-island		0.256***		0.0576		0.459***		0.258**		0.0588		0.459***
		(0.0878)		(0.0528)		(0.0479)		(0.111)		(0.0648)		(0.0679)
Training*Post 2013*Inter-island		0.196**		0.239***		0.0238		0.147		0.214***		0.0238
		(0.0834)		(0.0494)		(0.0455)		(0.108)		(0.0623)		(0.0660)
Intra-island Training (1 = Yes)		0.0000		-0.0000		-0.0000		0.0000		-0.0000		-0.0000
		(0.0621)		(0.0368)		(0.0339)		(0.0785)		(0.0452)		(0.0478)
Inter-island Training (1 = Yes)		-0.0000		-0.0000		-0.0000		-0.0000		-0.0000		-0.0000
		(0.0591)		(0.0350)		(0.0323)		(0.0765)		(0.0441)		(0.0466)
Year of 2013	0.0329	0.0329	0.0132	0.0132	0.0000	0.0000						-0.0000
	(0.0274)	(0.0270)	(0.0166)	(0.0160)	(0.0180)	(0.0147)						(0.0475)
Constant	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000						
	(0.0191)	(0.0189)	(0.0116)	(0.0112)	(0.0126)	(0.0103)						
Observations	612	612	609	609	612	612	237	237	234	234	237	237
Number of hhid	311	311	311	311	311	311	119	119	119	119	119	119
R-Squared	0.304	0.328	0.0569	0.129	0.127	0.418	0.263	0.296	0.0510	0.146	0.0829	0.389
P-value of Hausman test	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

*Estimation is based on Random-Effects Instrumental Variable models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result.*

calated" their source of advice: to communicate more with agricultural specialists upon returning from the training.

5.6.3 *Effects of Network Centrality on Technology Diffusion and Adoption*

Effects of training participants' degree centrality, closeness centrality, and betweenness centrality on information diffusion and technology adoption are presented in Table 22, Table 23, and Table 24. The results indicate that training effects are different across all centrality measures. In Table 23 column 4, participants with high closeness centrality is found to have higher likelihood of adopting grafting technique post training by 45.6 percentage points.

Clearly, different centrality measures signify different implication to the spread of information. Degree Centrality is clearly a local index while Betweenness and Closeness are global since they rely on network-wide geodesic paths (Freeman, 1979; Nomikos et al., 2014). Degree-centrality may be a suitable tool to establish connection within a community, because the most popular person should have the highest number of friends. However, to obtain information, one should be near from everyone. In this sense, the node in the nearest position on average can most efficiently obtain information, making closeness centrality is more appropriate to analyse. Furthermore, to control information flow, a node should be between other nodes because the node can interrupt information flow between them, making betweenness centrality appropriate to examine.

I found that for adoption of more complex technology, namely the grafting methods, people with the nearest position with everyone may have higher chance to implement it, while not so much for having the highest number of friends. **This finding supports the fifth hypothesis, that an influential individual who are relatively near to everyone in their locale may demonstrate better information collection ability thus is more adept at implementing more complicated technology**.

5.6.4 *Information Spillover from Training Participants to Non-training Participants*

Lastly, spillover effects from training participants to all farmers in general and to non-training participants post training are elaborated in Table 25 and Table 26. Table 25 shows that after the training no significant spillover are found from training participants to all farmers in general, indicating that advice network who are trained participants did not significantly influence the diffusion and adoption of technology for all farmers. Although in general, column 2 and 4 show that spillover from training participants on all farmers in general appears strongly on the diffusion and adoption of grafting.

Spillover to the non-participants are examined in Column 7 to 12. Column 12 suggests that post-training, such spillover are significant for the chemical fertilizer usage. Non-participants who seek advice from training participants are also associated with higher probability of knowing grafting, as indicated in column 8.

When location heterogeneity is taken into account, inter-island trained participants seem to significantly propel the adoption of organic and chemical fertilizer post training, as shown in Table 26 column 5 and 6. After returning from the training program, inter-island trained participants may have become even more active in promoting the usage of organic and chemical fertilizer to all farmers in general. No significant spillover are

Table 22: Effects of Participants' Degree Centrality on Technology Diffusion and Adoption

Variables	Know Water Conservation Technique	Know Grafting Technique	Adopt Water Conservation Technique	Adopt Grafting Technique	Adopting Organic Fertilizer	Adopting Chemical Fertilizer
	(1)	(2)	(3)	(4)	(5)	(6)
Degree*Training*Post2013	-0.245	-0.0306	-0.0957	0.248	0.212	-0.0633
	(0.191)	(0.153)	(0.230)	(0.176)	(0.275)	(0.304)
$\overline{\text{Degree} * \text{Training} * \text{Post2013}}$	0.335	0.111	-0.234	-0.0946	-0.690	0.686
	(0.317)	(0.256)	(0.403)	(0.318)	(0.478)	(0.497)
$\overline{\text{Degree Centrality}}$	0.0469	-0.0364	0.0633	0.183	0.239	-0.185
	(0.158)	(0.133)	(0.195)	(0.156)	(0.246)	(0.261)
Degree Centrality	0.103	0.106	0.103	-0.0340	0.0679	-0.0496
	(0.110)	(0.0932)	(0.132)	(0.102)	(0.167)	(0.186)
Training*Post2013	0.0422	0.00791	0.0598	-0.0694	-0.110	-0.0293
	(0.0648)	(0.0539)	(0.0770)	(0.0601)	(0.0969)	(0.107)
Training Dummy	-0.0240	0.0233	0.0205	-0.0236	0.274***	-0.155
	(0.0639)	(0.0530)	(0.0817)	(0.0642)	(0.0986)	(0.103)
Year of 2013	0.0645**	-0.00517	0.0301	-0.0469	0.103**	-0.0595
	(0.0320)	(0.0275)	(0.0379)	(0.0297)	(0.0492)	(0.0546)
Year of 2014	0.0550*	0.00834	0.0209	0.00305	0.0929*	-0.190***
	(0.0334)	(0.0289)	(0.0401)	(0.0313)	(0.0517)	(0.0575)
$\overline{\text{Post 2013}}$	0.0381	0.0331	-0.136	0.120	0.137	-0.0641
	(0.0706)	(0.0599)	(0.0945)	(0.0732)	(0.112)	(0.116)
Age of HH head	-0.00610**	-0.00455**	-0.00366	-0.000871	0.00127	-0.00387
	(0.00252)	(0.00217)	(0.00301)	(0.00234)	(0.00393)	(0.00430)
Years of education of HH head	-0.00521	-0.00918	-0.0103	0.0130	-0.0299**	-0.0228
	(0.00920)	(0.00795)	(0.0113)	(0.00851)	(0.0143)	(0.0158)
ROSCA (=1 if Yes)	0.159*	0.203***	-0.130	-0.143	0.426***	0.286**
	(0.0855)	(0.0731)	(0.114)	(0.0930)	(0.139)	(0.141)
Log of cultivated farmland	-0.0320	0.0484**	-0.00387	0.0367	-0.0468	0.0255
	(0.0249)	(0.0215)	(0.0315)	(0.0230)	(0.0384)	(0.0427)
$\overline{\text{Age of HH Head}}$	0.00729***	0.00445*	0.00698**	-0.000584	0.000684	0.00129
	(0.00281)	(0.00242)	(0.00341)	(0.00269)	(0.00443)	(0.00476)
$\overline{\text{Years of Education of HH Head}}$	0.0119	0.0117	0.0251**	-0.0152	0.0435***	0.0367**
	(0.0101)	(0.00872)	(0.0125)	(0.00957)	(0.0158)	(0.0172)
$\overline{\text{Log of Cultivated Farmland}}$	-0.00175	-0.0202	0.0479	-0.0193	0.0598	0.138**
	(0.0323)	(0.0278)	(0.0410)	(0.0324)	(0.0510)	(0.0545)
Constant	0.555***	0.710***	0.715***	0.873***	0.0149	0.880***
	(0.119)	(0.102)	(0.159)	(0.125)	(0.193)	(0.196)
Observations	681	688	614	647	688	688
Number of hhid	293	294	280	289	294	294
Village Fixed-Effects	YES	YES	YES	YES	YES	YES
R-squared	0.123	0.131	0.0956	0.107	0.101	0.187

*Estimation is based on Correlated Random Effects Instrumental Variable model. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5%, and 10% level, respectively. All training dummy variables are instrumented by all lottery (invitation) result variables.*

Table 23: Effects of Participants' Closeness Centrality on Technology Diffusion and Adoption

Variables	Know Water Conservation Technique	Know Grafting Technique	Adopt Water Conservation Technique	Adopt Grafting Technique	Adopting Organic Fertilizer	Adopting Chemical Fertilizer
	(1)	(2)	(3)	(4)	(5)	(6)
Closeness*Training*Post2013	-0.141	0.109	-0.207	0.456**	-0.0952	-0.388
	(0.219)	(0.154)	(0.281)	(0.196)	(0.281)	(0.302)
$\overline{Closeness * Training * Post2013}$	0.350	-0.0780	-0.158	-0.219	-0.478	0.187
	(0.277)	(0.219)	(0.355)	(0.264)	(0.405)	(0.430)
$\overline{Closeness\ Centrality}$	-0.119	-0.0326	0.0579	0.300	0.369	-0.0665
	(0.211)	(0.172)	(0.244)	(0.192)	(0.316)	(0.338)
Closeness Centrality	0.241*	0.174	0.125	-0.0928	0.0605	-0.0232
	(0.137)	(0.110)	(0.157)	(0.121)	(0.200)	(0.217)
Training*Post2013	0.0435	-0.0401	0.195	-0.225**	-0.0202	0.154
	(0.124)	(0.0896)	(0.155)	(0.112)	(0.164)	(0.176)
Training Dummy	-0.0785	0.0525	-0.00195	0.0237	0.328**	-0.102
	(0.102)	(0.0815)	(0.132)	(0.0982)	(0.151)	(0.160)
Year of 2013	0.0676**	-0.0183	0.00863	-0.0679**	0.117**	-0.0373
	(0.0334)	(0.0278)	(0.0377)	(0.0295)	(0.0503)	(0.0546)
Year of 2014	0.0647*	-0.00626	-0.0138	-0.0219	0.0907*	-0.186***
	(0.0344)	(0.0289)	(0.0391)	(0.0308)	(0.0523)	(0.0568)
$\overline{Post\ 2013}$	0.00152	0.0417	-0.108	0.152**	0.152	-0.0403
	(0.0777)	(0.0632)	(0.0994)	(0.0739)	(0.117)	(0.124)
Age of HH head	-0.00624**	-0.00460**	-0.00409	-0.00046	0.00124	-0.00375
	(0.00262)	(0.00218)	(0.00299)	(0.00233)	(0.00397)	(0.00429)
Years of education of HH head	-0.00507	-0.0109	-0.0139	0.0122	-0.0299**	-0.0213
	(0.00970)	(0.00811)	(0.0113)	(0.00863)	(0.0147)	(0.0160)
ROSCA (=1 if Yes)	0.151*	0.197***	-0.142	-0.156*	0.436***	0.235*
	(0.0873)	(0.0713)	(0.112)	(0.0863)	(0.133)	(0.140)
Log of cultivated farmland	-0.0349	0.0473**	-0.00171	0.0388*	-0.0466	0.0292
	(0.0261)	(0.0218)	(0.0315)	(0.0233)	(0.0395)	(0.0429)
$\overline{Age\ of\ HH\ Head}$	0.00767***	0.00482**	0.00809**	-0.00103	0.00131	0.00137
	(0.00294)	(0.00244)	(0.00343)	(0.00266)	(0.00447)	(0.00480)
$\overline{Years\ of\ Education\ of\ HH\ Head}$	0.0130	0.0129	0.0313**	-0.0141	0.046***	0.0389**
	(0.0108)	(0.00893)	(0.0127)	(0.00968)	(0.0163)	(0.0176)
$\overline{Log\ of\ Cultivated\ Farmland}$	0.000949	-0.0230	0.0308	-0.0307	0.0611	0.140**
	(0.0344)	(0.0284)	(0.0418)	(0.0324)	(0.0521)	(0.0559)
Constant	0.535***	0.651***	0.617***	0.801***	-0.209	0.833***
	(0.166)	(0.135)	(0.212)	(0.157)	(0.251)	(0.266)
Observations	639	645	572	607	645	645
Number of hhid	277	278	264	273	278	278
Village Fixed-Effects	YES	YES	YES	YES	YES	YES
R-squared	0.120	0.136	0.107	0.117	0.108	0.204

*Estimation is based on Correlated Random Effects Instrumental Variable model. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5%, and 10% level, respectively. All training dummy variables are instrumented by all lottery (invitation) result variables.*

Table 24: Effects of Participants' Betweenness Centrality on Technology Diffusion and Adoption

Variables	Know Water Conservation Technique	Know Grafting Technique	Adopt Water Conservation Technique	Adopt Grafting Technique	Adopting Organic Fertilizer	Adopting Chemical Fertilizer
	(1)	(2)	(3)	(4)	(5)	(6)
Betweenness*Training*Post2013	-0.193	-0.264	-0.378	0.254	0.658	0.184
	(0.309)	(0.265)	(0.376)	(0.279)	(0.472)	(0.525)
$\overline{\text{Betweenness} * \text{Training} * \text{Post2013}}$	0.00630	0.0569	-0.142	-0.0848	-0.481	1.378
	(0.517)	(0.433)	(0.646)	(0.490)	(0.801)	(0.846)
$\overline{\text{Betweenness Centrality}}$	0.0959	0.0930	-0.0438	0.365	0.698	-0.427
	(0.300)	(0.252)	(0.361)	(0.281)	(0.464)	(0.494)
Betweenness Centrality	0.187	0.199	0.356	-0.156	-0.741**	-0.469
	(0.211)	(0.183)	(0.244)	(0.190)	(0.325)	(0.362)
Training*Post2013	-0.000472	0.0171	0.0550	-0.0275	-0.0939	-0.0401
	(0.0535)	(0.0458)	(0.0631)	(0.0492)	(0.0816)	(0.0907)
Training	0.0291	0.0379	-0.00390	-0.0354	0.186**	-0.116
	(0.0486)	(0.0411)	(0.0608)	(0.0476)	(0.0760)	(0.0804)
Year of 2013	0.0545*	-0.0113	0.0247	-0.0434	0.0983**	-0.0583
	(0.0310)	(0.0268)	(0.0365)	(0.0286)	(0.0476)	(0.0530)
Year of 2014	0.0444	-0.00389	0.0111	0.00168	0.0859*	-0.181***
	(0.0315)	(0.0273)	(0.0374)	(0.0293)	(0.0485)	(0.0540)
$\overline{\text{Post 2013}}$	0.0505	0.0465	-0.144	0.106	0.0854	-0.0739
	(0.0689)	(0.0582)	(0.0910)	(0.0702)	(0.110)	(0.113)
Age of HH head	-0.0058**	-0.0043**	-0.00375	-0.000774	0.00120	-0.00388
	(0.00252)	(0.00217)	(0.00302)	(0.00234)	(0.00392)	(0.00428)
Years of education of HH head	-0.00511	-0.00927	-0.0106	0.0136	-0.0276*	-0.0223
	(0.00920)	(0.00794)	(0.0113)	(0.00851)	(0.0142)	(0.0157)
ROSCA (=1 if Yes)	0.141*	0.195***	-0.117	-0.164*	0.436***	0.256*
	(0.0843)	(0.0712)	(0.111)	(0.0904)	(0.137)	(0.137)
Log of cultivated farmland	-0.0308	0.0519**	-0.00113	0.0382*	-0.0470	0.0225
	(0.0249)	(0.0215)	(0.0315)	(0.0231)	(0.0382)	(0.0426)
$\overline{\text{Age of HH head}}$	0.00706**	0.00414*	0.00694**	-0.000567	0.000926	0.00183
	(0.00282)	(0.00243)	(0.00343)	(0.00270)	(0.00444)	(0.00476)
$\overline{\text{Years of Education of HH Head}}$	0.0124	0.0116	0.0249**	-0.0151	0.0426***	0.0384**
	(0.0101)	(0.00871)	(0.0125)	(0.00956)	(0.0158)	(0.0171)
$\overline{\text{Log of Cultivated Farmland}}$	0.00256	-0.0227	0.0500	-0.0188	0.0692	0.137**
	(0.0323)	(0.0277)	(0.0409)	(0.0322)	(0.0509)	(0.0542)
Constant	0.605***	0.732***	0.763***	0.930***	0.124	0.825***
	(0.112)	(0.0950)	(0.147)	(0.117)	(0.182)	(0.183)
Observations	681	688	614	647	688	688
Number of hhid	293	294	280	289	294	294
Village Fixed-Effects	YES	YES	YES	YES	YES	YES
R-squared	0.117	0.133	0.0934	0.106	0.0991	0.194

*Estimation is based on Correlated Random Effects Instrumental Variable model. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5%, and 10% level, respectively. All training dummy variables are instrumented by all lottery (invitation) result variables.*

found for the non-training participants though.
This indicates that after the training, only advice network who went to inter-island training location found to have significantly become more enthusiastic to pass the information they acquired from the training to farmers in general to some extent. They have successfully influenced fellow farmers to use organic and chemical fertilizer upon returning from the training. All training participants in general appear to become more involved in promoting the fertilizer usage to some extent to the non-training participants.
Having more advice network who went to the training is also associated with higher chance to get familiar with agricultural techniques to both farmers in general and the non-participants, but not for adoption.
Training participants have successfully driven fertilizer adoption to non-training participants to some extent, hence supporting the sixth hypothesis. When taking account the effects of location heterogeneity, spillover is present for the usage of chemical and organic fertilizer, especially for those who networked with inter-island training participants post training. No similar effects are observed amongst non-participants though.

5.7 DISCUSSION AND CONCLUSION

This research carried out a social experiment in the form of providing institutionalized training at different locations to encourage technology adoption by facilitating deeper social learning, both among fellow farmers and between farmers and agriculture experts. To see the effects of location, institutionalized training is conducted in farmers' hometown, a district located in the same province (intra-island location) and on neighboring, more developed island (inter-island location). Impact assessment examines training effectiveness as well as various possible social learnings that stemmed from the training, and how they explain linkages to the diffusion and adoption of technologies.

The result indicates that, training, regardless of locations, may have helped improve farmers' knowledge, but only training held in the most remote place manages to spur technology adoption. Despite being held for only three days, training in general may have helped to increase farmers' knowledge regarding two particular agriculture technologies that became the focus of the local government's campaign to improve the area's agriculture: soil- and water-conservation (dead-end trench technique) and plant-revitalization (grafting methods). Furthermore, farmers who participated in the training held at an inter-island location are found to particularly increase their adoption of the dead-end trench technique after learning how to implement it. The impact of Inter-island training location supports the proposed hypothesis: a farther-away training location help may increase the probability of technology adoption.

Nevertheless, this impact of training upon adoption is not clear-cut. A number of possible explanations can mediate between training and adoption behavior, and most are contributed by the social-network effects:

First, the farmers who went to the training are initially expected to increase their bonds with fellow participants from the same training group upon returning. However, that is not the case in this study. Conversely, in the medium run or at a time span greater than one year post-training, farmers who were members of inter-island training group are found to have stronger networks with people who did not go to training at all, instead of people from the same or different training groups. Deeper analysis shows that in the short term, farmers who went to the inter-island training may have

Table 25: Information spillover from training participants to non-training participants

Variables	All Farmers						Non-training Participants					
	Knowing soil and water conservation technique	Knowing grafting methods	Adopting soil and water conservation technique on condition of knowing it	Adopting grafting method on condition of knowing it	Currently using organic fertilizer	Currently using chemical fertilizer	Knowing soil and water conservation technique	Knowing grafting methods	Adopting soil and water conservation technique on condition of knowing it	Adopting grafting method on condition of knowing it	Currently using organic fertilizer	Currently using chemical fertilizer
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
No of Information Source who are Training Participants * Post2013	0.00859	-0.00876	0.00452	-0.00200	0.0194	0.0231	0.00944	-0.00338	0.00285	-0.0117	0.0188	0.0502*
	(0.0152)	(0.0143)	(0.0174)	(0.0141)	(0.0231)	(0.0246)	(0.0194)	(0.0192)	(0.0214)	(0.0177)	(0.0292)	(0.0293)
No of Information Source who are Training Participants	0.00944	0.0261**	0.0190	0.0181*	-0.00375	-0.0131	0.0153	0.0281**	0.0172	0.0174	-0.00677	-0.0220
	(0.0115)	(0.0108)	(0.0133)	(0.0109)	(0.0175)	(0.0187)	(0.0137)	(0.0136)	(0.0151)	(0.0127)	(0.0206)	(0.0209)
Training*Post 2013	0.0474	0.0405	0.0312	-0.0290	-0.00743	-0.0144						
	(0.0465)	(0.0432)	(0.0536)	(0.0414)	(0.0697)	(0.0737)						
Training (1 = Yes)	-0.00686	0.0195	0.000274	0.0167	0.0849	-0.0609						
	(0.0418)	(0.0395)	(0.0503)	(0.0403)	(0.0635)	(0.0686)						
Year of 2013	0.0214	0.00998	0.0177	-0.00705	0.0316	-0.0849	0.0431	0.0275	0.00802	-0.0246	0.0420	-0.123**
	(0.0342)	(0.0319)	(0.0396)	(0.0319)	(0.0516)	(0.0547)	(0.0373)	(0.0366)	(0.0413)	(0.0344)	(0.0562)	(0.0558)
Year of 2014	0.0171	0.0379	0.0285	0.0288	0.0191	-0.264***	0.00800	0.0429	0.0323	0.0523	0.00454	-0.307***
	(0.0331)	(0.0310)	(0.0388)	(0.0309)	(0.0500)	(0.0530)	(0.0358)	(0.0352)	(0.0403)	(0.0330)	(0.0540)	(0.0537)
Constant	0.870***	0.861***	0.834***	0.891***	0.688***	0.772***	0.861***	0.849***	0.842***	0.901***	0.715***	0.794***
	(0.0278)	(0.0263)	(0.0335)	(0.0276)	(0.0423)	(0.0456)	(0.0286)	(0.0284)	(0.0332)	(0.0274)	(0.0426)	(0.0441)
Observations	888	899	795	827	899	899	543	549	481	496	549	549
Number of hhid	311	311	306	309	311	311	192	192	189	190	192	192
Prob > Chi^2	0.0721	0.0181	0.179	0.250	0.264	0.0000	0.103	0.108	0.524	0.0298	0.571	0.0000
P-value of Hausman test	0.000	0.6086	0.0085	0.000	0.0310	0.0005	0.8196	0.9559	0.0896	0.3915	0.0324	0.3184

*Estimation is based on Random-Effects Instrumental Variable models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result. No of information sources who are training participants are instrumented with no of information sources who are selected to participate according to lottery (invitation) result.*

Table 26: Information spillover from training participants from different training group to non-training participants

Variables	All Farmers						Non-training Participants					
	Knowing soil and water conservation technique	Knowing grafting methods	Adopting soil and water conservation technique on condition of knowing it	Adopting grafting method on condition of knowing it	Currently using organic fertilizer	Currently using chemical fertilizer	Knowing soil and water conservation technique	Knowing grafting methods	Adopting soil and water conservation technique on condition of knowing it	Adopting grafting method on condition of knowing it	Currently using organic fertilizer	Currently using chemical fertilizer
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
No of Information Source who are Intra-island Training Participants * Post 2013	-0.00962	0.0505	-0.0599	0.0289	0.0245	-0.00500	0.0461	0.0721	-0.0571	0.0402	0.0516	0.117
	(0.0500)	(0.0452)	(0.0587)	(0.0474)	(0.0749)	(0.0807)	(0.0727)	(0.0715)	(0.0810)	(0.0663)	(0.109)	(0.110)
No of Information Source who are Intra-island Training Participants	0.0147	0.000488	0.0175	-0.0176	-0.0369	0.00523	-0.0389	-0.0113	-0.0291	-0.0137	-0.0364	-0.0685
	(0.0392)	(0.0363)	(0.0460)	(0.0368)	(0.0589)	(0.0631)	(0.0561)	(0.0554)	(0.0623)	(0.0505)	(0.0839)	(0.0855)
No of Information Source who are Inter-island Training Participants * Post 2013	0.00125	0.0494	-0.0657	-0.0173	0.122*	0.149**	0.0502	0.0861	-0.0952	-0.0159	0.0394	0.0876
	(0.0426)	(0.0385)	(0.0491)	(0.0396)	(0.0641)	(0.0692)	(0.0576)	(0.0563)	(0.0614)	(0.0512)	(0.0862)	(0.0863)
No of Information Source who are Inter-island Training Participants	0.00560	-0.0133	0.0615	-0.00546	-0.0452	0.0135	-0.00748	-0.0251	0.0612	0.00405	0.0453	0.0198
	(0.0358)	(0.0333)	(0.0409)	(0.0331)	(0.0540)	(0.0578)	(0.0484)	(0.0474)	(0.0524)	(0.0428)	(0.0716)	(0.0732)
No of Information Source who are Training Participants * Post 2013	0.0125	-0.0428	0.0522	-0.00211	-0.0411	-0.0384	-0.0255	-0.0559	0.0552	-0.0142	-0.0110	-0.0172
	(0.0308)	(0.0278)	(0.0364)	(0.0293)	(0.0463)	(0.0500)	(0.0409)	(0.0401)	(0.0447)	(0.0371)	(0.0613)	(0.0615)
No of Information Source who are Training Participants	0.00124	0.0295	-0.0136	0.0249	0.0252	-0.0196	0.0304	0.0421	-0.00294	0.0191	-0.0164	-0.0104
	(0.0249)	(0.0232)	(0.0293)	(0.0234)	(0.0377)	(0.0403)	(0.0339)	(0.0333)	(0.0370)	(0.0304)	(0.0504)	(0.0515)
Training*Post 2013*Intra-island	-0.139*	-0.0768	0.0965	0.12000	-0.0616	-0.0987						
	(0.0801)	(0.0708)	(0.0954)	(0.0735)	(0.120)	(0.131)						
Training*Post 2013*Inter-island	-0.107	-0.0333	0.196**	0.0951	0.00112	-0.107						
	(0.0775)	(0.0681)	(0.0923)	(0.0717)	(0.116)	(0.126)						
Training*Post 2013	0.127**	0.0685	-0.0610	-0.104*	0.0133	0.0576						
	(0.0642)	(0.0567)	(0.0769)	(0.0604)	(0.0964)	(0.105)						
Intra-island Training (1 = Yes)	0.147*	0.0913	-0.00586	-0.0682	0.129	0.0162						
	(0.0769)	(0.0795)	(0.0896)	(0.0727)	(0.118)	(0.124)						
Inter-island Training (1 = Yes)	0.151**	0.0283	-0.0449	-0.0336	0.0735	0.153						
	(0.0744)	(0.0762)	(0.0867)	(0.0705)	(0.113)	(0.119)						
Training (1 = Yes)	-0.107*	-0.0191	0.0149	0.0518	0.0191	-0.121						
	(0.0615)	(0.0634)	(0.0717)	(0.0591)	(0.0943)	(0.0989)						
Year of 2013	0.0193	0.0138	0.00831	-0.00691	0.0344	-0.0867	0.0441	0.0281	0.00590	-0.0240	0.0398	-0.123**
	(0.0332)	(0.0297)	(0.0395)	(0.0319)	(0.0499)	(0.0541)	(0.0373)	(0.0366)	(0.0409)	(0.0343)	(0.0562)	(0.0560)
Year of 2014	0.0152	0.0395	0.0199	0.0291	0.0198	-0.266***	0.00869	0.0395	0.0332	0.0504	0.00135	-0.311***
	(0.0321)	(0.0286)	(0.0387)	(0.0308)	(0.0482)	(0.0523)	(0.0359)	(0.0353)	(0.0400)	(0.0331)	(0.0543)	(0.0540)
Constant	0.872***	0.862***	0.839***	0.892***	0.688***	0.772***	0.859***	0.849***	0.846***	0.901***	0.716***	0.793***
	(0.0281)	(0.0281)	(0.0333)	(0.0276)	(0.0429)	(0.0453)	(0.0286)	(0.0284)	(0.0330)	(0.0275)	(0.0426)	(0.0441)
Observations	888	899	795	827	899	899	543	549	481	496	549	549
Number of hhid	311	311	306	309	311	311	192	192	189	190	192	192
P-value of Hausman test	0.9783	0.9998	0.0170	0.6467	0.9555	0.4177	0.6087	0.6354	0.4864	0.5650	0.2042	0.2995

*Estimation is based on Random-Effects Instrumental Variables models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result. No of information sources who are training participants are instrumented with no of information sources who are selected to participate according to lottery (invitation) result.*

more frequent face-to-face contact with their agriculture informants. Even though the direction of networks and the question of how the communication is first initiated are unknown, this could be attributed to two causes:

- Inter-island training-group farmers may be seen as being more knowledgeable among their peers, hence they may became more popular among people who did not go to the training at all. In addition, non-trained farmers are probably the ones who first approach these trained farmers to get more information regarding agricultural practices.

- Or the opposite dynamic could be in operation. These farmers may intend to showcase their training results following their return from a different island. These inter-island farmers perceived that they had gone through a more memorable, exciting, and different experience than farmers from the other training groups. They were probably more inclined to tell people, particularly the non-participants, about what they learned, hence they had more intense communication with non-participants.

  For the inter-island training participants, this increasing networking intensity with their agriculture informants and non-participants might reflect their motivation and eagerness to practice post-training what they learned. Still, ties with peers may not be strong enough to lead to the decision to adopt the technologies.

Second, the farmers who went to the training are also expected to increase communication with the experts. This study has found evidence supporting this proposed hypothesis, namely that farmers who went to inter-island training were also found to have increased significantly their contact with extension agents post-training. This finding may indicate that that these farmers may have "escalated" their source of advice from their peers or fellow farmers to the experts, i.e. the extension agents.

Third, a positive Hawthorne effect probably seems to be in operation regarding technology adoption for those joining the inter-island training. Farmers may feel more motivated by the new locale and novel experience they obtained by visiting a new, faraway, and exotic location than by the training itself. They could possibly have become more open-minded and innovative, which thus provides the households with a new perspective on performing agricultural techniques. Their effort to attend the inter-island training might be much more prodigious than that required by those attending either hometown or intra-island training. Intra- and inter-island trainings are both carried out within a three-nights-and-four-day time frame. Even though the time spent together with fellow trainees was similar, the intensity of communication post-training is fairly different between the two training groups. This fact might reflect their accumulation of experience during the training, which later manifests in the magnitude of social learning and eventually the adoption of better agricultural practices.

Fourth, perhaps what the influential farmers did in the remote area as well as the situation in the pilot farm in that place may have altered Tanggamus farmers' expected returns of agricultural techniques. What prominent farmers did in their farmland and their success stories may have altered the way farmers think about the technologies thus revising the expected return of adoption after they interact with them. This may explain the reasons why inter-island training participants talked more with others: they witness the farmers in the more advanced area to do things differently.

Evidence on the positive effect of centrality on knowledge acquisition for farmers in general is also found. Farmers who are influential, or nominated many farmers group members in their local farming community, tend to possess higher likelihood to understand more complex technology, namely grafting methods and to use chemical fertilizer. Different centrality measures signify different implication to the spread of information. Degree-centrality is clearly a local index while Betweenness- and Closeness-centrality are global since they rely on network-wide geodesic paths, making the last 2 measures more appropriate in explaining the adoption of technology in this study.

Further examination also confirmed that spillover may be present from training participants to non-training participants, particularly the adoption of fertilizer to some extent. Non-participants who networked with training participants post training are possibly experiencing higher likelihood to use fertilizer. Further, farmers in general who networked with inter-island trained participants post training may also have higher probability of using fertilizer. People who have ties with training participants are more likely to adopt technologies due to strong enforcement and encouragements from them, but only to some extent. Adoption requires a change in perspective and attitude to advance farming practices, and having more "innovative" people as encouragement may not be enough to entirely implement the techniques in their farmland.

This chapter offers important implications for policy-makers: the interplay between these two categories of relationships, namely networking with peers and experts, through formally conducted training, may have strongly contributed to changing farmers' mindsets regarding agriculture technology adoption, particularly for the laggards. Future agricultural training or workshops should not be disregarded, and more emphasis should be placed on the specific training environment and experience while still ensuring the quality of the training's content. A set of relationship and connection amongst agrarian actors should be strongly taken into consideration, as these informal sources of information are possibly the strongest enforcer for technology dissemination and adoption in the rural community.

6

REDUCING AGRICULTURAL INCOME VULNERABILITIES THROUGH AGROFORESTRY TRAINING: EXPERIENCE FROM POORER HOUSEHOLDS

6.1 INTRODUCTION

Improving rural livelihood has been a continuous challenge faced by developing countries where threats of food security and environmental deterioration on fragile agriculture lands problems collide with income vulnerability. Agroforestry is currently seen as an alternative paradigm for rural development worldwide that is centered on species-rich, low-input agricultural techniques including a diverse array of crops, rather than on high-input monocultures with only a small set of staple food crops (Leakey, 2001a,b). Some forms of agroforestry techniques require low external inputs (pro-poor) and efficient integration of trees, making them good candidate for achieving both sustainable livelihood and ecological objectives (Koohafkan et al., 2012). The simplest and most traditional agroforestry practices are to diversify crops or inter-cropping. Economically, agroforestry can diversify farm operations (Caviglia-Harris and Sills, 2005) and livelihood strategies (Cramb and Culasero, 2003)–to reduce risk and increase resilience, especially for smallholder farmers (Lin, 2011). In the longer term, agroforestry can reduce poverty by enhancing farm income (Leakey and Tchoundjeu, 2001), providing provision for fodder, fuelwood, and medicinal purposes (Akinnifesi et al., 2008), generating employment (Asaah et al., 2011), ensuring food security (Garrity et al., 2010), and enhancing livelihood opportunities (Leakey et al., 2005). Agroforestry can bring not only economic but also environmental benefit, including soil and water conservation (Bekele-Tesemma, 1997), increased soil fertility (Young, 1989), and improved or maintained surroundings (Regmi, 2003).

Development intervention promoting agroforestry varies, from participatory programs incorporating both technical training and knowledge sharing to improve ecological and economic well-being (Fischer and Vasseur, 2002; Asaah et al., 2011), to various financial aid programs in the form of subsidies to diversify farm management and encourage forest-tree planting (Mehta and Leuschner, 1997; Carvalho et al., 2002; Thacher et al., 1996). Educating people about conservation and preservation is a necessity in preventing environmental degradation, but the content should be suitable to farmers' interest. To address this, interventions designed to increase investment in human capital, amongst other methods of intervention, are more favorable, as not only they provide farmers with theories and practical knowledge regarding the correct techniques, but also encourage positive attitude changes resulting from various interactions with agrarian actors during and upon returning from the training.

Most impact assessments largely focus on measuring adoption, yields, and economic gains–poverty reduction was assumed to follow. The research challenges lie in how to differentiate the poorer within the community; and how to assess whether the technologies are relevant to the poor and how they affect them. Little attention was given to differentiating between farmers with different levels of assets and different social characteristics, ability to adopt, and the ultimate economic outcomes of adoption. This chapter aims to fill the gap in explaining linkage amongst the variables of economic, ecological and social aspects of agroforestry, using the situation and condition of rural Indonesian livelihood. To serve the purpose, I carried out randomized-controlled trial to select coffee and/or cocoa farmers in the region for participating in institutionalized training. Program evaluation spans in two-year period, ensuring that I captured the short- and mid-term impact of the program.

I found that farmers who are generally poorer tend to diversify more after returning from the training, in contrast to the general training participants who reduce crop diversity. Perceived agroforestry benefits are strikingly different across poorer and relatively well-off farmers. The former reported that agroforestry has improved their food incomes and provided provisions for medicinal purposes, while the latter testified that they experienced conserved soil and water, and obtained provision for fuelwood. Further, poorer farmers are found to increase their depth and size of network upon returning from the training program, which is likely to influence agroforestry adoption. Positive associations between centrality measures and adoption of agroforestry practices are also identified, in addition to significant spillover from training participants to non-participants on promotion of such practices. Finally, I discovered that crop diversity in medium-term is negatively correlated with income vulnerability. Increased income for poorer farmers is obtained from legume crops commodities, which shows a significant upsurge after returning from the training. The rest of the chapter is organized as follow: Section 6.2 provides theoretical ground and hypothesis; Section 6.3 elaborates the agricultural management in Tanggamus; Section 6.4 describes the descriptive statistics; Section 6.5 builds on empirical strategy; Section 6.6 draws the estimation results and finally Section 6.7 concludes with discussion and policy recommendation.

6.2 CONCEPTUAL FRAMEWORK

This chapter aims to examine the impact of institutionalized training upon agroforestry adoption, perceived benefits, and eventually farm income stability. Hypothesis are formulated based on the program evaluation of the randomized controlled trial. To serve the purpose, I present several hypotheses:

Hypothesis 7: Training participants will have higher index of plant diversification relative to non-participants.

For a successful adoption, agroforestry techniques should be compatible with local practices and traditions, and also farmers' beliefs, values and social system (Barr and Cary, 2000). Awareness of possible new practices is not sufficient to ensure their implementation. I consider training as intervention because behavior change plays bigger role than technical and financial consideration (Kilpatrick et al., 2003); and values and attitudes must change before behavior changes (Kilpatrick and Johns, 2003). In training, farmers are exposed to new channels of knowledge and opportunity to interact with trainers (agricultural experts) and fellow training participants (peers). These features in training are expected to have crucial role in propelling the implementation of agricultural technologies.

Adoption patterns between small and large farmers may differ. For medium and large farms, fallow and extensive grazing are still important and intensive agroforestry systems may not yet be economically appropriate. In contrast, for smallholders intensive system may be more interesting but food security and risk issues play a more critical role than for large farmers. Poorer farmers may find agroforestry profitable, but the adoption is often hampered by limited land, labor, and capital resources and their need to ensure food security and reduce risks. Netting (1993) suggests that the main strategy for combining high production per unit area with risk reduction and sustainability in agriculture is diversification, indicating its suitability for poorer farmers. Agroforestry systems that offer short-term benefits are preferable, as the mechanism allows farmers to sustain longer-term investments in agroforestry.

Hypothesis 8: Training participants will have better awareness on perceived agroforestry benefits relative to non-participants.

Environmental and economic benefits of agroforestry are recognized. Ecological benefits include improving soil and water conservation and improved surrounding due to woody trees, while economic benefits captured in this study are the chances of reducing complete crop failure, provision for medicinal purposes and fuelwood. Pastur et al. (2012) posits that farmers who do acknowledge the merits of agroforestry will incorporate certain techniques into their farming practices if they can afford it.

Hypothesis 9: Upon returning, training participants are expected to have enlarged their network depth and size, which influenced adoption.

Farmers who have larger networks are more likely to make changes in their practice. Rogers and Sheppard (2010) concluded that early adopters have greater social participation after examining studies in agricultural and non-agricultural settings in developed and developing countries. Interaction with others including neighbors, experts, and families have influence on changing values and attitudes (Wood, 2000). Thus, farmers who participate in agricultural and community organizations are more likely to adopt innovations because not only do they become aware of a wider variety of new practices, they also have opportunity to test and change values and attitudes. Network mechanism amongst poorer- and well-off farmers may likely differ, as social status within villages affects outcomes of dissemination methods. The former will possibly solicit more information from peers, while the latter may primarily obtain knowledge from agricultural specialists (extension agents).

Hypothesis 10: Farmers who possess higher centrality scores may be more adept in procuring information thus having higher likelihood to practice more agroforestry.

An individual who have more connections to other individual and at the same time hold central position in their local community, may be very likely to be an influential individual. These people may have access to the resources in their network and their opinion is also most likely to heard by other members. Sparrowe et al. (2001) has shown that Individual centrality in an advice network is positively associated with individual performance. Innovations and performance can be produced if the actors occupy central network position that provide access to new knowledge developed by other units, even though it may be dependent on an individual's capacity to replicate new knowledge (Tsai, 2001). Farmers who inhibit the most central position in their network is more likely to be innovative, making them a strong candidate to be an early adopter of agroforestry practices.

Hypothesis 11: Training participants regardless of income group have higher propensity to diffuse knowledge regarding agroforestry practices to non-training participants.

All training participants, in spite of the different income groups, are presumed to increase their communication intensity with their agricultural advice network upon returning from the training. As information is embedded in social interactions (Granovetter, 1973), knowledge from the training is also more likely to be transferred from training participants to non-participants. Chapter 5 shows the positive spillover from training participants to non-training participants though it has yet to spur adoption. As agroforestry benefits are informed during the training course, farmers may be able to understand its merits thus accelerating the implementation of agroforestry practices in their community. In this chapter, I expect to see positive association between network ties to training participants and adoption of more agroforestry practices for non-training participants.

Hypothesis 12: In the medium to long-term timeline, agroforestry adoption will have indirect impact reducing income vulnerabilities especially for poorer farmers.

To cope with risk, vulnerable households can smooth the income by making conservative production or employment choices and diversifying economic activities (Morduch, 1995). Diversified production provides smallholders with the opportunity to select a particular crop or crops for commercial production (such as coffee or cocoa in the area) in order to increase farm-generated income while meeting the increasing demands for local produce. Based on previous studies such as Omamo (1998) and Gaiha and Imai* (2004) who demonstrated that crop diversification reduces vulnerabilities, I hypothesize that crop diversification will generally reduce households' income variation, which will primarily benefit poorer farmers and protect them from external shocks.

6.3 AGRICULTURAL MANAGEMENT IN TANGGAMUS

Farm management in Tanggamus varies from traditional shaded coffee-garden to complex agroforestry system that combines many species of trees with various types of agricultural crops. Traditional agroforestry practices, such as the planting of fruit trees in home gardens and close to family dwellings are prevalent amongst shareholders farmers. Tree garden systems are known to maintain high-quality soil while conserving water (Castillo and Toledo, 2000; van Noordwijk et al., 2011). Apart from coffee and cocoa as the main cash crops, farmers benefit from various provisions such as firewood, fodder, fruits, and medicinal plants. In the study area, annual crop plants such as rice, cucumber, tomato; perennial fruits such as banana, papaya, avocado, durian, snake fruit (*Salak*); perennial industrial crops such as cocoa, coffee, coconut, rubber, and oil-palm; perennial herbs such as ginger, nutmeg, pepper, long pepper, chili; perennial vegetables such as breadfruit, eggplant, cabbage, and wood plants such as teak, albasia, and mahogany are cultivated. Unlike annual crops, perennials are planted once and live for years, producing many consecutive harvests. Farm management is on an extractive basis, with few inputs such as fertilizer and organic pest management allocated to maintain productivity. Labor is most of the case provided by family members and usually focused on tree maintenance and product harvesting. Lampung is a major producer of fruit for sale to national markets, but the realities at the farmer level belittle this positive macroeconomic indicator. Farmers primarily focus their resources on the production of commodity crops. Usually fruit and other horticultural products from tree gardens are intended for household consumption and local market sale. Management of those crops remains traditional, with few resources allocated to their production.

Official extension system in Indonesia is carried out through farmer groups, following Law 16/2006 on Extension System for Agricultural, Fishery and Forestry (Neilson, 2008) . A farmer group consists of farmers living in nearby neighborhoods and cultivating the same commodity of interest. It usually comprises 20 to 30 people living in the same neighborhood, but may not necessarily represent everyone in a village. One or two extension workers are assigned to each group to monitor the farmers' progress and advances at least once a month through monthly group meetings.

6.4 DESCRIPTIVE STATISTICS

6.4.1 *Descriptive Statistics of Training Participants by Income Group*

As indicated in Figure 6, this study was carried out between September 2012 and September 2014. The 2012 baseline survey was conducted to all household heads in 16 randomly selected coffee- and cocoa-producing farming groups in the district of Tanggamus, in Pulau Panggung and Sumberejo sub-districts, which are the district's top producing areas. During the September 2012 survey, I administered the questionnaire to 312 out of the 398 households (~80%). Face-to-face interview was carried out to self-identified household heads, which particularly asked about their socio-economic characteristics, agricultural activities, as well as agricultural advice network.

The baseline survey found that farmers' median annual farm income is around Rp. 12,800,000 (or US$ 1000). Most farmers belong to smallholder category with the average cultivated land of 1 hectare.

In April 2013, I invited half of the surveyed farmers (152 people) to join agricultural training in different locations. The invited 156 farmers were randomly placed into three groups according to the location where their training would be conducted. Of the total 156 farmers, 52 farmers were randomly assigned to each one of the three training locations. Table 27 shows the actual number of training participants, which is 120 out of the 156 invited farmers, or around 79%. Specifically, 39 farmers (75%) were able to participate in the training in their hometown, 39 (75%) attended training in intra-island location but still located in the same province, and 42 (81%) participated in inter-island training, respectively. Distribution is even amongst poorer farmers and relatively well-off farmers, indicating that randomization works well. Accommodation, food, and travel insurance during the trip were provided for farmers participating in intra-island and inter-island training.

Two professional trainers from the Indonesian Coffee and Cocoa Research Institute (ICCRI) were invited to provide lectures during the first two days, comprise in-class seminars

Table 27: Training participation by income category

	Non-invited respondents		Invited by lottery				Training participation rate
			Participating respondents		Non-participating respondents		
	Below Median Farm Income	Above Median Farm Income	Below Median Farm Income	Above Median Farm Income	Below Median Farm Income	Above Median Farm Income	
Training in hometown			19 (6%)	20 (6%)	5 (2%)	8 (3%)	75%
Training in intra-island			20 (6%)	19 (6%)	7 (2%)	6 (2%)	75%
Training in inter-island			20 (6%)	22 (7%)	3 (1%)	7 (2%)	81%
Total	82 (26%)	77 (25%)	59 (49%)	61 (20%)	15 (5%)	21 (7%)	
	156 (50%)		120 (38.5%)		36 (11.5%)		
Grand Total	312 (100%)						

regarding coffee and cocoa cultivation respectively. The trainers and training-program materials were identical at each location, with nearby training (hometown) is carried out first, followed by intra-island, and inter-island respectively. I ensured that all training locations offered similar environments. The in-class training materials for coffee and cocoa on the first and second days consisted of basic cultivation training, such as (1) information on shade trees, crop diversification, and the perceived benefits both environmentally and economically; (2) information on fertilizer, including ways to procure organic fertilizers from livestock and to make compost from leaves residue; (3) ways to select high-yield varieties and pruning methods. The third day primarily consisted of a pilot-farm visit where trainers gave practical information regarding ways to maintain a plantation using the situation and conditions in the pilot farm as an example. During the pilot farm visit, farmers were introduced to selected prominent farmers in the district who were chosen to represent the district. Farmers got the opportunities to exchange information and ideas in this occasions even after the training program ends, as farmers can swap contact information between each other. This enables farmers to maintain contact and facilitate future cooperation. Moreover, training programs in remote-location, namely in intra- and inter-island, have incorporated recreations to visit touristy places in the district.

6.4.2 *Descriptive Statistics of Agroforestry and Social Network by Income Group*

Table 28 displays the general household characteristics of the invited and uninvited groups to confirm our randomization process. Education, income, and community characteristics do not significantly differ between invited and uninvited farmers. Regardless of income category, household heads are on average in their 40s, have 8 years of formal education (do not complete middle school), and possess at least one mobile phone or motorbike. Farmers possess 1.2 hectares farmland, with the below-median income farmers having less than 1 hectares (0.8 Ha). Income from agricultural activities on average are between 18-19 million Rp. (or US$ 1300~1400) annually. Above-median farm income farmers obtain around 27 million Rp. (~US$ 2100) while their below-median farm income counterparts earn 9-10 million Rp. (~US$ 700) annually, indicating that the gap is relatively big for these two income groups.

Farmers with above-average farm income category cultivate around 2.8 crop categories and 3.7 crop diversities, compared to 2.4 plant categories and 3 plant diversities for those belong to below-median farm income category. Majority of these crops comprise industrial crops, spices, and fruits crops. Only very few farmers cultivate legume crops and vegetable crops in their farmland.

Post-evaluation surveys were conducted twice, in September 2013 and then in September 2014, making a three years panel dataset. Table 29 shows whether diversification pattern changed due to training participation. All farmers in general reported a significant increase in the number of crop cultivated, both by category and by diversity. Even so, non-training participants are seen to contribute more to this than non participants. On average, farmers cultivate more fruit crops followed by spice crops. Training participants have significantly increased their fruit crops cultivation, while non-training participants have planted more spice and fruit crops. However, all respondents in general are found to have significantly decreasing their legume crops cultivation. In terms of perceived benefits, all respondents testified that they significantly felt the conserved soil and water happening in their farmland. However, for provision for medicinal purpose, only training participants felt the benefits.

Lastly, Table 30 illustrates various social network variables. Richer training participants in general talk significantly more with their agricultural informants compared to poorer training participants. However, after the training, the difference becomes no longer significant.

6.5 EMPIRICAL METHODOLOGY

6.5.1 *Dependent Variables*

This study attempts to see the impact of institutionalized trainings upon the difference in adoption patterns of agroforestry between low- and high-income farmers. I found that farm income is skewed towards low income; hence I regard poorer farmers as those whose income falls below median farm income. As an addition, this study distinguishes between the impact of training in general, and the impact of training on different income group. In particular, I intend to examine whether training has had any impact upon these variables:

1. **The agroforestry index**
   Table 31 exhibits the list of crops that farmers cultivate within the study period in the area. Crops are categorized according to its functions with the the following breakdown: rice and corn as cereal; dogfruit, petai, almond, peanut, and soybean as legume; coffee, cocoa, coconut, rubber, tobacco, and palm as industrial crops; pepper, chili, nutmeg, clove, and ginger as spices; tomato, cabbage, eggplant, and cucumber as vegetables; banana, durian, snakefruit (salak), papaya, durian, and avocado as fruits; albasia, teak, and mahogany as hardwood.
   Two agroforestry indexes are formulated, the first being the crop diversity, or simply the number of crops i.e. rice, corn, peanut, soybean, coffee, cocoa, etc; and second being the crop category, or the number of crops according to the category, which are cereal crops, legume crops, industrial crops, spice crops, fruit crops, vegetable crops, and hardwood. As one of the training's major theme is about agroforestry or agricultural diversification, I expect to see how training can influence household decision to diversify their agricultural produce.

2. **The perceived benefits of agroforestry**
   For those cultivating more than 1 commodity, I asked whether farmers feel the benefits of agroforestry after they implemented agroforestry (that is Agroforestry Index

Table 28: Descriptive statistics of the invited and uninvited farmers

Variable	Not Invited to Training						Invited to Training					
	All		Above Median Farm Income		Below Median Farm Income		All		Above Median Farm Income		Below Median Farm Income	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Household Characteristics												
Age of Household head	46.81	11.79	46.10	11.43	47.46	12.1	44.66	10.85	45.32	10.45	43.88	11.26
Household head Years of Education	8.43	3.55	8.62	3.53	8.254	3.577	8.31	3.23	8.40	3.09	8.21	3.40
Owned farmland	1.20	1.072	1.55	1.26	0.87	0.71	1.11	0.90	1.36	0.98	0.83	0.70
Log of owned farmland	-0.1	0.75	0.19	0.71	-0.4	0.69	-0.1	0.76	0.14	0.66	-0.4	0.75
Cultivated farmland	1.15	0.98	1.50	1.15	0.82	0.64	1.09	0.86	1.32	0.93	0.835	0.67
Log of cultivated farmland	-0.1	0.78	0.19	0.69	-0.4	0.768	-0.1	0.71	0.14	0.63	-0.4	0.70
Farm income (in million Rp)	18	25.2	27.1	30.6	10.1	15.4	19	28.5	27.4	31.1	9.4	21.6
Log of farm income	16.08	1.26	16.71	0.97	15.5	1.23	16.15	1.22	16.74	0.96	15.48	1.14
No. of Mobile Phone	1.64	1.14	1.73	1.18	1.553	1.101	1.58	1.15	1.74	1.17	1.40	1.09
Coefficient of Variation of Farm Income	67.62	37.99	58.80	36.20	75.58	37.87	57.11	36.19	53.15	33.20	61.62	38.93
No. of Motorbike	1.34	0.87	1.47	0.91	1.224	0.825	1.45	0.99	1.68	1.04	1.19	0.85
Walking distance to farmland (in minutes)	19.62	21.89	20.20	17.73	19.11	24.99	24.67	62.02	32.26	84.47	16.41	12.38
Walking distance to paved road (in minutes)	3.42	6.74	3.58	6.70	3.272	6.781	4.08	7.97	3.42	6.95	4.80	8.94
Observations	477		231		246		456		240		216	
Agriculture Characteristics												
Agroforestry Index (by crop category)	2.58	1.04	2.79	1.04	2.39	0.99	2.70	1.02	2.86	0.99	2.52	1.02
Agroforestry Index (by crop type)	3.34	1.47	3.70	1.47	3.01	1.39	3.38	1.34	3.55	1.28	3.20	1.37
Cereal (= 1 if planting)	0.19	0.40	0.18	0.39	0.21	0.41	0.15	0.36	0.15	0.35	0.16	0.37
Legume (= 1 if planting)	0.05	0.21	0.07	0.26	0.02	0.14	0.09	0.29	0.11	0.31	0.08	0.27
Industrial Crop (= 1 if planting)	0.93	0.26	0.96	0.20	0.90	0.30	0.95	0.21	0.97	0.17	0.94	0.25
Spice (= 1 if planting)	0.59	0.49	0.71	0.46	0.48	0.50	0.60	0.49	0.69	0.46	0.51	0.50
Vegetable (= 1 if planting)	0.03	0.17	0.04	0.19	0.02	0.15	0.03	0.18	0.03	0.16	0.04	0.20
Fruit (= 1 if planting)	0.66	0.47	0.71	0.45	0.62	0.49	0.73	0.44	0.78	0.42	0.68	0.47
Hardwood (= 1 if planting)	0.15	0.36	0.16	0.36	0.15	0.36	0.14	0.35	0.15	0.36	0.13	0.34
Observations	477		231		246		456		240		216	
Perceived Benefit of Diversification (Only in 2012 and 2013)												
Conserved Soil and Water (= 1 if experiencing)	0.47	0.50	0.49	0.50	0.45	0.50	0.50	0.50	0.54	0.50	0.46	0.50
Reducing Crop Failure (= 1 if experiencing)	0.51	0.50	0.55	0.50	0.48	0.50	0.49	0.50	0.48	0.50	0.51	0.50
Procuring for Medicinal Purpose (= 1 if experiencing)	0.15	0.36	0.14	0.35	0.16	0.37	0.15	0.36	0.13	0.34	0.17	0.38
Procuring for Fuelwood (= 1 if experiencing)	0.75	0.43	0.78	0.42	0.73	0.45	0.80	0.40	0.81	0.39	0.78	0.41
Improved Surrounding (= 1 if experiencing)	0.78	0.42	0.79	0.41	0.76	0.43	0.85	0.36	0.87	0.34	0.82	0.39
Observations	318		154		164		304		160		144	

Table 29: Descriptive statistics of the agroforestry diffusion and adoption prior to and after the training

Variables	All Farmers			Training Participants			Non-Training Participants			Mean Difference[1]	
	Before Training	After Training	Diff.	Before Training	After Training	Diff.	Before Training	After Training	Diff.	Before Training	After Training
Agroforestry Index (by crop category)	2.39 (1.11)	2.76 (0.96)	0.371***	2.52 (1.12)	2.80 (0.93)	0.277**	2.307 (1.09)	2.736 (0.98)	0.429***	0.222**	0.069
Agroforestry Index (by crop diversity)	3.14 (1.56)	3.47 (1.31)	0.337***	3.27 (1.48)	3.50 (1.25)	0.22	3.05 (1.60)	3.46 (1.34)	0.406**	0.22	0.04
Cereal (= 1 if planting)	0.176 (0.38)	0.173 (0.38)	-0.003	0.126 (0.33)	0.147 (0.35)	0.021	0.208 (0.41)	0.190 (0.39)	0.018	-0.082*	-0.043
Legume (= 1 if planting)	0.093 (0.29)	0.057 (0.23)	-0.03**	0.126 (0.333)	0.075 (0.26)	-0.05	0.072 (0.26)	0.046 (0.21)	0.02	0.053	0.029
Industrial Crops (= 1 if planting)	0.945 (0.23)	0.938 (0.24)	-0.006	0.974 (0.15)	0.953 (0.21)	0.021	0.927 (0.26)	0.929 (0.26)	0.002	0.047*	0.024
Spice (= 1 if planting)	0.508 (0.50)	0.639 (0.48)	0.131***	0.537 (0.50)	0.626 (0.48)	0.088	0.489 (0.50)	0.648 (0.48)	0.158***	0.048	0.022
Vegetable (= 1 if planting)	0.038 (0.19)	0.028 (0.17)	-0.009	0.025 (0.157)	0.037 (0.19)	0.012	0.046 (0.21)	0.023 (0.15)	0.023	-0.021	0.014
Fruit (= 1 if planting)	0.524 (0.50)	0.782 (0.41)	0.258***	0.613 (0.489)	0.844 (0.36)	0.231***	0.468 (0.50)	0.744 (0.44)	0.276***	0.144**	0.099***
Hardwood (= 1 if planting)	0.135 (0.34)	0.154 (0.36)	0.019	0.142 (0.351)	0.134 (0.34)	0.008	0.130 (0.34)	0.166 (0.37)	0.036	0.012	-0.032
Conserved Soil and Water (= 1 if experiencing)	0.389 (0.49)	0.581 (0.494)	0.192***	0.361 (0.482)	0.647 (0.48)	0.285***	0.406 (0.49)	0.541 (0.50)	0.135***	0.044	0.105*
Reducing Crop Failure (= 1 if experiencing)	0.511 (0.50)	0.49 (0.50)	-0.019	0.487 (0.546)	0.501 (0.50)	0.058	0.526 (0.50)	0.458 (0.50)	0.0677	-0.038	0.087
Procure for Medicinal Purpose (= 1 if experiencing)	0.147 (0.36)	0.154 (0.36)	0.006	0.100 (0.30)	0.21 (0.41)	0.109**	0.177 (0.38)	0.119 (0.33)	0.057	-0.076*	0.090**
Procure for Fuelwood (= 1 if experiencing)	0.82 (0.38)	0.726 (0.45)	-0.096***	0.831 (0.375)	0.773 (0.42)	0.058	0.817 (0.39)	0.697 (0.46)	-0.119***	0.014	0.075
Improved Surrounding (= 1 if experiencing)	0.794 (0.40)	0.826 (0.38)	0.032	0.831 (0.375)	0.890 (0.31)	0.058	0.770 (0.42)	0.786 (0.41)	0.015	0.061	0.104**
Log of Farm Income	16.19 (1.29)	16.06 (1.216)	-0.129	16.203 (1.13)	16.049 (1.17)	0.154	16.19 (1.37)	16.079 (1.24)	0.114	0.0095	0.029

[1] (Between Training Participant vs Non-training Participant)

*Standard deviations are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*

Table 30: Summary statistics of farmers' network by income category

	All Farmers (Participants and Non-participants)						All Training Participants						Non-training participants					
	Before Training			After Training			Before Training			After Training			Before Training			After Training		
	Below Median Farm Income	Above Median Farm Income	Diff.	Below Median Farm Income	Above Median Farm Income	Diff.	Below Median Farm Income	Above Median Farm Income	Diff.	Below Median Farm Income	Above Median Farm Income	Diff.	Below Median Farm Income	Above Median Farm Income	Diff.	Below Median Farm Income	Above Median Farm Income	Diff.
Number of advice network who went to the same training location							0.61 (0.87)	0.52 (0.85)	-0.09	0.491 (0.72)	0.39 (0.625)	-0.1						
Number of advice network who went to the different training location							0.77 (0.87)	1 (1.02)	0.22	0.78 (1.06)	0.73 (1.02)	-0.05						
Number of advice network who did not go to the training[1]							2.71 (2.13)	4.76 (3.60)	2.1***	2.83 (1.95)	3.80 (2.61)	0.9**						
Number of advice network whom respondent meets frequently[2,3]	2.73 (3.14)	3.76 (3.62)	1.0***	1.38 (2.65)	1.49 (2.31)	0.10	2.37 (2.52)	3.84 (2.98)	1.47**	1.46 (2.36)	1.51 (2.72)	0.047	2.95 (3.47)	3.71 (3.97)	0.76	1.33 (2.29)	1.47 (2.61)	0.14
Know extension agent and have frequent contact[3,4,5]	0.188 (0.39)	0.26 (0.44)	0.07	0.22 (0.42)	0.18 (0.38)	-0.03	0.135 (0.35)	0.28 (0.45)	0.14**	0.254 (0.44)	0.26 (0.445)	0.01	0.22 (0.41)	0.25 (0.43)	0.02	0.2 (0.40)	0.13 (0.34)	-0.06
Know professional trainers from Indonesian Coffee and Cocoa Research Institute (ICCRI)[3,4]							0.00 (0)	0.00 (0)	0	0.38 (0.49)	0.45 (0.07)	0.07						
Know contact farmers from inter-island training location[3,4]							0.00 (0)	0.00 (0)	0	0.068 (0.2556)	0.12 (0.31)	0.05						
Know contact farmers from intra-island training location[3,4]							0.00 (0)	0.00 (0)	0	0.12 (0.33)	0.18 (0.39)	0.06						
Out-degree Centrality[6]	0.262 (0.153)	0.341 (0.221)	0.079***	0.212 (0.148)	0.254 (0.163)	0.04***	0.253 (0.161)	0.329 (0.277)	0.07*	0.229 (0.166)	0.253 (0.174)	0.024	0.267 (0.149)	0.35 (0.217)	0.08***	0.201 (0.134)	0.254 (0.155)	0.05***
Out-closeness Centrality[6]	0.532 (0.093)	0.575 (0.1338)	0.041***	0.598 (1.416)	0.561 (1.48)	-0.03	0.518 (0.100)	0.572 (0.142)	0.05**	0.528 (0.1558)	0.573 (0.1447)	0.044**	0.541 (0.088)	0.578 (0.128)	0.037**	0.644 (1.827)	0.553 (0.143)	-0.09
Betweenness Centrality[6]	0.052 (0.0886)	0.068 (0.87)	0.015	0.050 (0.082)	0.087 (0.126)	0.036***	0.054 (0.108)	0.0685 (0.087)	0.0143	0.056 (0.0818)	0.101 (0.153)	0.044**	0.051 (0.074)	0.068 (0.088)	0.0167	0.047 (0.082)	0.07 (0.101)	0.02***
No of network who are training participants	1.014 (1.43)	1.05 (1.48)	0.035	1.41 (1.229)	1.34 (1.201)	-0.071	1.05 (1.25)	1.19 (1.306)	0.014	1.58 (1.29)	1.33 (1.218)	-0.252	0.99 (1.47)	0.97 (1.56)	- 0.0197	1.30 (1.07)	1.34 (1.192)	0.046
No of network who are invited to training	1.18 (1.55)	1.37 (1.89)	0.184	1.67 (1.275)	1.68 (1.29)	0.010	1.20 (1.42)	1.57 (1.827)	0.373	1.81 (1.34)	1.613 (1.224)	-0.196	1.177 (1.63)	1.26 (1.921)	0.086	1.58 (1.22)	1.74 (1.33)	0.151

[1] *(May or may not be farmers)*; [2] *(Meet at least once every 1,2 days)*; [3] *(= 1 if Yes)*; [4] *(Only available in 2012 and 2013)*; [5] *(Have contact at least once every 2 weeks)*;
[6] *(Only applicable for those who listed farmers group members as agricultural informants)*

by crop diversity > 1 or Agroforestry Index by crop category > 1). Amongst the perceived benefits covered in this study is environmental benefits and economic benefits. Environmental benefits encompass conserved soil and water and improved surroundings, while economic benefits consist of reducing complete chances of crop failure, procuring for medicinal purposes, and provision for fuelwood. For an adoption of agroforestry to take place, farmers have to be knowledgeable regarding the benefits that come from it. Training functions to spread awareness regarding such benefits, thus can alter households' attitudes toward adopting the diversification.

3. **Network of training participants upon returning from training**
   During the training, farmers get exposed with new information, training experience, as well as numerous contact farmers. As farmers tend to discuss with others, particularly with people in their farmers group regarding farming activities, I intend to see how their training experience has shaped or changed their communication pattern with their advice network. To solicit information regarding their network, I ask farmers all the name of those people they sought information from, then I identify whether their advice network belong to the same training group, different training group, or people who do not go to the training at all.

4. **Network with peers and experts for all respondents**
   In the rural area, extension officials are becoming one of the most important information source for farmers regarding agricultural management. Farmers who know an extension agent and have frequent contact with them are commonly believe to be able to get firsthand information and innovation pertains to farming management. All respondents are asked whether they know an extension agent (knowing means mutually, so they could contact them directly) and whether they communicate frequently or at least once every two weeks. Apart from network with experts, ties with peers or agricultural informants and their frequency of meetings are also explored, namely advice network both from within the farmers' group or outside the farmers' group. Training is also expected to have altered farmers network patterns with agricultural specialists.

5. **Personal Network with bridging ties**
   In this training program, I introduce farmers to new bridging ties, namely professional trainers from the national research institute, and contact farmers from the neighboring district and island. While only participants trained in intra- and inter-island are exposed to network with influential person from across district and island, all training participants in general have the opportunity to interact personally with trainers even after the training ends. As almost all farmers possess mobile phone, they can easily contact these bridging ties to exchange ideas and knowledge regardless of location.

6. **Income smoothing**
   Farmers who diversify their agricultural produce is more likely to have lower income variation. The more number of crops enable them to cope with the risk of complete crop failure and other risks associated with market and climatic condition. To examine the relationship between agricultural diversification and income smoothing, I employ coefficient of variation (CV) of farmers' farm income within 3 years timespan. The Coefficient of Variation is a distribution's standard deviation

Table 31: List of crops cultivated in the study area

Cereal Crops	Legume Crops	Industrial Crops	Spice Crops	Vegetable Crops	Fruit Crops	Hardwood
Rice	Soybean	Coffee (Arabica)	Chili	Cabbage	Durian	Teak
Corn	‘Petai	Coffee (Robusta)	Nutmeg	Cucumber	Snakefruit	Mahogany
	Peanut	Tobacco	Clove	Eggplant	Banana	Albasia
	Almond	Cocoa		Tomato	Avocado	Jabon
	Dogfruit	Palm			Papaya	Other Wood
		Coconut				
		Areca				

divided by its mean. To check for robustness, I use the real value and log value of farm income.

6.5.2 *Estimation Strategy*

As is always the case with impact-evaluation studies, participation in training is likely to cause a self-selection bias. Although I randomly invited farmers to participate and Table 20 shows that on average no differences exist between invited and non-invited farmers, the decision of whether to participate in training is ultimately the farmer’s choice and thus the model may suffer from endogeneity in this variable. To examine the pure effect of training participation, I employ the Local Average Treatment Effect (LATE) model and instrument the participation status with random invitation status. Thus, I report the treatment effect on the treated (TOT) rather than the intention-to-treat (ITT) effects. Among the models tested are the Fixed-Effect and Random-Effects instrumental variable models. However, due to the Hausman-test result, which supported the validity of employing the Random-Effects model in most of the model, in addition to the ability to fit more into the data and the analysis, I decided to employ the Random-Effects-IV model as follows:

1. Effects of Training on Agroforestry Index

$$AgroforestryIndex_{i,t} = \alpha + \beta_1 T_{i,t} * Y + \beta_2 T_{i,t} + \beta_3 T_{i,t} * Y * LowIncome + \beta_4 T_{i,t} * LowIncome + \beta_5 LowIncome + \beta_6 Y + u_i + w_{i,t}$$

2. Effects of Training on Perceived Benefits of Agroforestry on Condition of Practicing It

$$PerceivedBenefit_{i,t} = \alpha + \beta_1 T_{i,t} * Y + \beta_2 T_{i,t} + \beta_3 T_{i,t} * Y * LowIncome + \beta_4 T_{i,t} * LowIncome + \beta_5 LowIncome + \beta_6 Y + u_i + w_{i,t} \text{ if Agroforestry Index} > 1$$

where i is the household head in year t. In Estimation 1, the dependent variable is agroforestry index. The independent variable is the interaction term between the training participation dummy (T) and the year of post-2013 (Y), to see the impact of training upon adoption. I also construct the same interaction term for poorer farmers ($LowIncome$), which is farmers with below median farm income.

In Estimation 2, the dependent variable is perceived benefits of agroforestry, or the dummy variable of agroforestry benefits (Y = 1 if experienced the benefits) predicated on the condition of cultivating more than 1 category or diversity in the farmland. These perception variables are only available in 2012 and 2013.

To investigate the causes of agroforestry adoption, further analysis are employed, on how farmers' social networks have changed due to training and how this network contributes to farmers' agricultural diversification. For this I have the following model:

3. Effects of Training on Various Social Network Variables (Poorer vs Richer Farmers)

$$AdviceNetwork_{i,t} = \alpha + \beta_1 T_{i,t} * Y + \beta_2 T_{i,t} + \beta_3 T_{i,t} * Y * LowIncome + \beta_4 T_{i,t} * LowIncome + \beta_5 LowIncome + \beta_6 Y + u_i + w_{i,t}$$

In Estimation 3, the dependent variable is various social network variables. Variable construction method is as follow: farmers have to recall the names of people outside their household from whom they seek advice, can learn from, or from whom they can generally obtain useful information about farming practices, particularly about coffee and/or cocoa. For this part, I am trying to investigate the impact of the training upon four personal-network variables, namely:

(PN1) Training participants' agricultural network upon returning from training
This stands for the investigation whether training participants increase their communication intensity with fellow farmers who went to the same training group, a different training group, or farmers who did not go to the training at all.

(PN2) Training participants' personal network with bridging ties upon returning from training
Training participants got exposed with possible bridging ties (namely trainers and influential contact farmers) that can connect participants to access knowledge from their locale to the outside world. Professional trainers, were introduced to the training participants during the course of the training. Trainers gave their mobile numbers to the participants so they can access them personally even after the training ends. Influential contact farmers on the other hand, are introduced to farmers who undertook training in intra-island and inter-island locations throughout the pilot farm visit. During the visit, participants are able to exchange mobile numbers with these contact farmers, so outside the training realm they can possibly exchange information regarding farming practices.
This variable examines farmers' network extension outside their community, whether they "know" some bridging ties as the source of advice and keep communicate with them. "Knowing" has to be mutual. So, if a farmer says they know a person, then, that person should also know that farmer. "Knowing" also means that the farmer can directly contact the person when needed. However, data on networking with bridging ties are only available for 2012 and 2013.

(PN3) Farmers' meeting frequency with their agricultural informants
This variable represents whether training has had any impact upon farmers' meeting frequency with agricultural informants in general.

(PN4) Farmers' network ties with agricultural specialists
This variable examines farmers' communication frequency with agricultural specialists, namely extension agents. Extension agents are regarded as more advanced sources of information than fellow farmers and are readily accessible for consultation. However, data on networking with experts are only available for 2012 and 2013.

4. Effects of Network Position on Agroforestry Adoption

Previously, Section 4 concludes that one's position in their locale matters for learning outcomes, as farmers who occupy the central position in their network tend to have better information processing ability. This part intends to see whether such effects present in the household's decision to diversify their agricultural produce.
Network position is measured based on information regarding advice network from inside the farmers group (peers advice network). In the questionnaire, farmers are asked the names of people outside their household from whom they seek advice regarding farming practices from inside their farmers group. In group-level, farmers testified whom they obtained information from or talked to regarding agricultural practices, so the direction is outward. Network position can help explain the individual level of importance and influence within the group.
Network centrality can be a proxy to measure network position within the farmers group. The information needed to construct network centrality is the identifier of the individual who initiated the advice seeking (source) and the identifier of the individual who serves as the target of the advice seeking (target) from each farmers group that become the unit of the study. In this chapter, the variable of interest is centrality measures of training participants post training ($Centrality_{i,t} * T_{i,t} * Y$). Three kinds of centrality measures are computed, namely degree-centrality, closeness-centrality and betweenness centrality (see Section 4.5 for reference).
However, network position is likely to be correlated with other individual-specific unobserved variables that positively impact agroforestry adoption. For instance, richer training participants tend to have higher centrality scores to begin with compared to the poorer participants. Therefore, the between effect (and the estimate from the random intercept model, which is a weighted average of the between and within estimates), may overestimate the effect of network position (Wooldridge, 2010). In such cases, a correlated random-effects model becomes an alternative because of it can estimate the within effects in random effect models (Allison, 2009; Schunck, 2013; Mundlak, 1978). I perform the correlated random effects model as follow:

$$AgroforestryIndex_{i,t} = \alpha + \beta_1 Centrality_{i,t} * T_{i,t} * Y + \beta_2 Centrality_{i,t} + \beta_3 T_{i,t} * Y + \beta_4 T_{i,t} + \beta_5 T_{i,t} * Y * LowIncome + \beta_6 T_{i,t} * LowIncome + \beta_7 LowIncome + \beta_8 Y + \pi \overline{x_i} + u_i + w_{i,t} \text{ if Agricultural Advice Network} > 0$$

Estimation 4 examines the effects of farmers' network position in their local neighborhood on the agroforestry adoption post training using the correlated random effects (CRE) model. The CRE model relaxes the assumption of zero correlation between the level 2 (for example, subject) error and the level 1 (for example, occassions) variables by adding the cluster mean of $x_{i,t}$ which picks up any correlation between this variable and the level 2 error (Mundlak, 1978; Wooldridge, 2010).
Therefore, in this estimation, the variable of interest is $Centrality * Training_{i,t} * Post2013$. Effects of centrality measures in general on the adoption of agroforestry practices are also represented in $Centrality$.

5. Information Spillover from Training Participants to Non-training participants

$$AgroforestryIndex_{i,t} = \alpha + \beta_1 NetworkParticipants_{i,t} * T_{i,t} * Y + \beta_2 NetworkParticipants_{i,t} * LowIncome * T_{i,t} * Y + \beta_3 NetworkParticipants_{i,t} + \beta_4 NetworkParticipants_{i,t} * LowIncome + \beta_5 T_{i,t} * Y + \beta_6 T_{i,t} + \beta_7 T_{i,t} * Y * LowIncome + \beta_8 T_{i,t} * LowIncome + \beta_9 LowIncome + \beta_1 0Y + u_i + w_{i,t}$$ if Non-training Participants = 1

In Estimation 5, I particularly examine the spillover of training participants by income group on agroforestry practices to non-participants. For this estimation, separate regression is run for the non-training participants. The main variable of interest is network with training participants post training ($Network\ Participants_{i,t} * T_{i,t} * Y$), which is defined as farmers' agricultural advice network who attended the training. Farmers are asked from whom they get information pertaining to farming practices, and then I identify whether these individuals were selected to attend the training and have actually attended the training. This network variable may possibly be endogenous because those who diversify more may be influential thus already having more networks to begin with. Furthermore, this variable is treated as an independent variable in further analysis. To deal with endogeneity, social network with training participants is instrumented with social network with farmers who are invited to the training, as invitation to attend the training is randomized.

6. Effects of Agroforestry on Income Vulnerabilities

$$CV\ of\ Farm\ Income = \alpha + \beta_1 AgroforestryIndex + \beta_2 X + u_i$$

Finally, estimation 6 models the impact of agroforestry on income smoothing or coefficient of variation of farm income. I employ ordinary least square (OLS) for this estimation. The independent variables are various household characteristics.

6.6 RESULTS

6.6.1 *Effects of Training on Agroforestry Index*

Table 32 illustrates the regression results on agroforestry index, both according to their category and diversity. Column 1 to 4 showed that in general, training participants cultivate lesser crops than before the training by almost 0.5 points. However, relative to their richer counterparts, poorer farmers significantly increased their crop diversity or kept their crop category by 0.4 points even after crop and village dummies are controlled. General training participants may learn from the training that the commodities they are currently cultivating are not aligned with their livelihood strategies i.e. not suitable financially or environmentally, and that they better replace the less-profitable crops to specialize on the main cash crops. On the contrary, the poorer in the community behaves differently after the training, that they opt to increase the diversity or keep the number of crop category probably due to capital constraints. This finding may mean that: (1) The poor may be more knowledgeable regarding the benefits of diversifying their farm after the training, hence adapting their livelihood strategy to diversify their crops upon returning from the training program, or (2) Even if they intend to specialize on the main cash crops, they are unable to do so due to the capital constraints, hence keeping the number of crop category.

The fact that general training participants diversify less after the training proves that the seventh hypothesis is not supported. In order for agricultural practices to be adopted fully, farmers have to be aware of its merits. In this context, agroforestry may not be appropriate for farmers in general. However, this study provides more evidence that the poor behaves differently when it comes to diversifying their farm strategy, making agroforestry an effective measure for the poor to optimize their farm management.

6.6.2 *Effects of Training on Perceived Benefits of Agroforestry*

Table 33 exhibits the effects of training on perceived merits of agroforestry after implementing it in the farmland. Column 1 to 8 analyze the perceived benefits of agroforestry according to crop category, while column 9 to 16 provide similar analysis according to crop diversity. In column 1 to 4, all training participants reported that they benefit from diversification by crop category, particularly the conserved soil and water and the provision for fuelwood. In the case of poorer farmers in column 5 and 8, they testified that they benefited from the provision of medicinal purposes and increased food income. The weaker effects are seen in column 9 to 16 when similar analysis are conducted based on plant diversity or simply the number of crops cultivated. Only economic benefits are testified by both training participants in general and training participants coming from below median income category, namely the provision of fuelwood and medicinal purposes respectively.

The finding suggests that different perceived benefit is seen between lower vs. higher income training participants, in which the eighth hypothesis is supported. Higher income farmers tend to feel the environmental merits of diversification i.e. conserved soil and water and economical i.e. provision of fuelwood. On the other hand, lower income farmers benefit from medicinal purposes and increased food income. Franzel and Scherr (2002) argued that it is likely to take three to six years before agroforestry's ecological benefits begin to be fully realized compared to the few months needed to harvest and evaluate a new annual crop or method. The findings may mean that (1) for environmental benefits, agroforestry has delivered the merits since before the training, but farmers just realized it after the training due to increased knowledge, and (2) for economic benefits, the farmers are already informed regarding the advantages since before the training, but they experienced it after implementing the techniques post-training. Poorer farmers may have realized that diversifying the crops may help increasing food income, but they lack of knowledge regarding suitable crops or technical matters. After obtaining the correct knowledge, they implemented it in their farmland thus experiencing the benefits.

6.6.3 *Effects of Training upon Social Network Variables (Poorer vs Richer Farmers)*

Various social networks of training participants are examined in Table 34 and 35. Table 34 shows that generally training participants who belong to same training group do not significantly communicate amongst themselves upon returning, but they seemed to have less contact with agricultural informants who went to the different training loca-

Table 32: Effects of training on agroforestry index

Variables	Agroforestry Index					
	By Category	By Diversity	By Category	By Diversity	By Category	By Diversity
	(1)	(2)	(3)	(4)	(5)	(6)
Training * Post 2013 * Low Income	0.438**	0.474*	0.431**	0.479*	0.170*	0.118
	(0.217)	(0.282)	(0.218)	(0.281)	(0.0981)	(0.187)
Training * Post 2013	-0.496***	-0.470*	-0.468**	-0.424*	-0.191**	-0.0949
	(0.192)	(0.248)	(0.193)	(0.249)	(0.0872)	(0.166)
Training Dummy * Low Income	-0.213	0.115	-0.207	0.156	-0.119	0.374*
	(0.248)	(0.350)	(0.245)	(0.345)	(0.0953)	(0.222)
Training Dummy	0.419**	0.112	0.376*	0.0192	0.199	-0.295*
	(0.195)	(0.272)	(0.194)	(0.271)	(0.0784)	(0.177)
Below Median Farm Income	-0.406***	-0.685***	-0.413***	-0.744***	-0.00617	-0.202*
	(0.110)	(0.161)	(0.110)	(0.162)	(0.0395)	(0.104)
Year of 2013	0.653***	0.714***	0.629***	0.682***	0.179***	0.161**
	(0.0900)	(0.117)	(0.0910)	(0.118)	(0.0427)	(0.0821)
Year of 2014	0.303***	0.141	0.283***	0.108	-0.0314	-0.254***
	(0.0900)	(0.117)	(0.0907)	(0.117)	(0.0421)	(0.0811)
Cereal Crop[1]					0.971***	1.007***
					(0.0380)	(0.0821)
Legume Crop[1]					1.011***	1.070***
					(0.0515)	(0.112)
Industrial Crop[1]					1.033***	1.396***
					(0.0712)	(0.154)
Spice Crop[1]					0.959***	1.119***
					(0.0289)	(0.0626)
Vegetable Crop[1]					0.792***	0.749***
					(0.0808)	(0.175)
Fruit Crop[1]					1.059***	1.181***
					(0.0319)	(0.0708)
Age of Household Head					-0.000402	0.00543
					(0.00134)	(0.00335)
Years of Education of Household Head					0.000528	0.0259**
					(0.00420)	(0.0105)
Log of Cattle Value					-0.000371	0.00108
					(0.00218)	(0.00482)
No of Household Members					0.00482	0.0279
					(0.0102)	(0.0227)
Native[1]					0.00708	0.115
					(0.0583)	(0.155)
Second Generation Migrant[1]					0.0546*	-0.149*
					(0.0325)	(0.0855)
Log of Cultivated Farmland					-0.00512	0.1049**
					(0.0197)	(0.04540)
Constant	2.474***	3.416***	2.395***	3.494***	0.0190	-0.00610
	(0.0967)	(0.136)	(0.172)	(0.250)	(0.1262)	(0.295)
Village Fixed Effects	NO	NO	YES	YES	NO	NO
Observations	933	933	926	926	838	838
Number of Household id	311	311	311	311	310	310
R-squared	0.0870	0.0743	0.135	0.127	0.866	0.650
Hausman test	1.0000	0.000	0.996	0.994	0.9378	0.0002

[1] *(= 1 if Yes)*

*Estimation is based on Random-Effects models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result. Village dummies are not shown for brevity.*

Table 33: Effects of training on perceived benefits of agroforestry if adopting diversification (N crops > 1)

Variables	If Agroforestry Index by Category > 1								If Agroforestry Index by Diversity > 1							
	Conserved Soil and Water		Provision for Fuelwood		Provision for Medicinal Purposes		Increased Food Income		Conserved Soil and Water		Provision for Fuelwood		Provision for Medicinal Purposes		Increased Food Income	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Training * Post 2013 * Low Income	-0.146	-0.119	-0.142	-0.122	0.234**	0.255**	0.160	0.191*	-0.0967	-0.0686	-0.148	-0.127	0.244**	0.271**	0.141	0.161
	(0.148)	(0.152)	(0.113)	(0.114)	(0.118)	(0.118)	(0.111)	(0.113)	(0.142)	(0.146)	(0.108)	(0.110)	(0.115)	(0.115)	(0.106)	(0.107)
Training Dummy * Low Income	0.0443	-0.0364	0.103	0.0700	-0.0988	-0.180*	-0.108	-0.146	0.0199	-0.0658	0.0758	0.0443	-0.110	-0.189*	-0.0810	-0.105
	(0.141)	(0.143)	(0.109)	(0.107)	(0.105)	(0.108)	(0.113)	(0.113)	(0.136)	(0.137)	(0.105)	(0.102)	(0.102)	(0.104)	(0.108)	(0.109)
Training * Post 2013	0.233*	0.185	0.253**	0.246**	0.167	0.148	-0.00776	-0.0338	0.191	0.143	0.231**	0.214**	0.0964	0.0739	0.00870	-0.0263
	(0.130)	(0.135)	(0.0993)	(0.101)	(0.104)	(0.105)	(0.0976)	(0.0995)	(0.126)	(0.130)	(0.0957)	(0.0974)	(0.102)	(0.102)	(0.0943)	(0.0948)
Training Dummy	-0.0734	-0.00103	-0.107	-0.128	-0.142*	-0.0792	-0.0188	-0.00457	-0.0263	0.0444	-0.0894	-0.106	-0.0678	-0.00901	-0.0324	-0.0215
	(0.108)	(0.110)	(0.0833)	(0.0819)	(0.0812)	(0.0829)	(0.0860)	(0.0859)	(0.0948)	(0.105)	(0.0801)	(0.0786)	(0.0786)	(0.0801)	(0.0827)	(0.0832)
Below Median Farm Income	-0.0317	-0.00388	-0.00162	0.0508	0.0478	0.0670	-0.00670	0.0236	-0.0427	-0.0110	0.00431	0.0544	0.0387	0.0522	-0.0248	0.00247
	(0.0649)	(0.0664)	(0.0503)	(0.0494)	(0.0467)	(0.0494)	(0.0532)	(0.0538)	(0.0631)	(0.0639)	(0.0485)	(0.0475)	(0.0452)	(0.0476)	(0.0513)	(0.0526)
Year of 2013	0.151**	0.175***	-0.193***	-0.208***	-0.110**	-0.0997**	-0.0500	-0.0597	0.162***	0.184***	-0.186***	-0.199***	-0.0921**	-0.0804*	-0.0708*	-0.0747*
	(0.0586)	(0.0623)	(0.0447)	(0.0468)	(0.0469)	(0.0483)	(0.0440)	(0.0462)	(0.0557)	(0.0595)	(0.0424)	(0.0445)	(0.0453)	(0.0466)	(0.0419)	(0.0436)
Cereal Crops Dummy		-0.126**		-0.0301		8.13e-05		-0.0444		-0.118**		-0.0410		0.00742		-0.0649
		(0.0593)		(0.0443)		(0.0450)		(0.0458)		(0.0583)		(0.0435)		(0.0446)		(0.0450)
Legume Crops Dummy		-0.0780		0.0416		0.00984		0.0282		-0.0697		0.0400		0.00934		0.0212
		(0.0761)		(0.0568)		(0.0574)		(0.0596)		(0.0756)		(0.0564)		(0.0573)		(0.0595)
Industrial Crops Dummy		0.0371		0.519***		0.0379		0.0168		0.0392		0.534***		0.0384		0.0302
		(0.204)		(0.153)		(0.154)		(0.161)		(0.204)		(0.152)		(0.154)		(0.161)
Spice Crops Dummy		0.00230		0.104***		0.0436		0.129***		0.0228		0.0902**		0.0468		0.104***
		(0.0523)		(0.0391)		(0.0396)		(0.0407)		(0.0482)		(0.0359)		(0.0367)		(0.0375)
Vegetable Crops Dummy		0.0536		0.0434		0.0955		0.0662		0.0665		0.0968		0.157*		0.109
		(0.119)		(0.0892)		(0.0906)		(0.0924)		(0.117)		(0.0874)		(0.0895)		(0.0905)
Fruit Crops Dummy		-0.0431		0.0784*		-0.0435		0.120**		-0.00720		0.0579		-0.0354		0.0791*
		(0.0615)		(0.0459)		(0.0464)		(0.0480)		(0.0540)		(0.0402)		(0.0410)		(0.0422)
Hardwood Dummy		-0.0995*		-0.00978		-0.0573		-0.0412		-0.0915*		-0.0142		-0.0534		-0.0494
		(0.0536)		(0.0401)		(0.0407)		(0.0414)		(0.0524)		(0.0391)		(0.0400)		(0.0406)
Constant	0.433***	0.465**	0.917***	0.174	0.221***	0.0909	0.863***	0.771***	0.419***	0.421*	0.913***	0.162	0.201***	0.0608	0.882***	0.830***
	(0.0542)	(0.235)	(0.0418)	(0.176)	(0.0403)	(0.177)	(0.0434)	(0.186)	(0.0521)	(0.231)	(0.0399)	(0.172)	(0.0387)	(0.174)	(0.0415)	(0.184)
Village Fixed Effects	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Observations	511	506	511	506	511	506	511	506	544	539	544	539	544	539	544	539
Number of Household id	292	289	292	289	292	289	292	289	300	298	300	298	300	298	300	298
R-squared	0.0537	0.115	0.0317	0.104	0.0373	0.0983	0.00193	0.0593	0.0543	0.119	0.0327	0.108	0.0249	0.0862	0.00508	0.0519
Hausman test	0.0217	0.0918	0.259	0.0276	0.535	0.715	0.258	0.185	0.0089	0.0404	0.1715	0.0025	0.8552	0.5539	0.2606	0.6690

*Estimation is based on Random-Effects models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. Training dummy is instrumented by lottery (invitation) result.*

tion. However, column 3 shows that poorer training participants, tend to communicate more with people who did not go to the training at all. They are also found to meet more agricultural networks frequently, once every one or two days (column 4). Unfortunately, training participants from these income group do not significantly increase contact with agricultural specialists.

Connections with bridging ties, namely professional trainers and contact farmers from different district and inter-island, are shown in Table 35. Training participants on average maintain personal contact with trainers and selected prominent farmers they met during pilot farm visit. This relation is absent for poorer training participants though. It is either the poorer participants were reluctant to establish contact with these bridging ties, or the bridging ties who were hesitant to approach the poorer participants during the course of farm visit.

Though poorer participants seem to have increased the size and depth of agricultural network and richer training participants appear to have enlarged their network outreach, the latter is found to stop communicating with their agricultural informants who went to the different training group, hence not supporting the ninth hypothesis. Poorer training participants, who often are more marginalized and having less opportunity to improve their formal knowledge may have experienced changes in their mindset and attitude after the training. Upon returning, they are more likely to be pro-active in information gathering thus the significant increase in their network size relative to their richer counterparts. On the contrary, richer training participants seems likely to value new information more than the poor, making them less enthusiastic to exchange information with their network.

6.6.4 *Effects of Network Centrality on Agroforestry Index*

Effects of network centrality on agroforestry practices are observed in Table 36. Previously, chapter 4 and chapter 5 show evidence that farmers who occupy the central position in their local network structures tend to possess better problem solving skill ability and higher likelihood to be an early adopter.

In this chapter however, the result indicates that the effects of centrality are different across income groups. Table 36 column 1 and 2 show that richer farmers with higher degree centrality tend to reduce agroforestry index by both category and diversity by 1.6 and 1.8 points respectively; as opposed to poorer farmers with the higher degree centrality who appear to increase the index by category and diversity by 1.3 and 2.2 respectively. Furthermore, column 6 shows that the highest possible betweenness centrality score for poorer farmers is associated with higher diversity index by 3.8 points.

Degree-centrality, which represents one's popularity in their local network, is found to encourage poorer farmers to cultivate more crops due to strong enforcement from their locale. Betweenness-centrality, a proxy to control information flow which examine how many times a node is located between other nodes, is also found to have positive association to higher diversity for poorer farmers. Serving as an intermediary between two nodes can interrupt information flow between them, making the middlemen at advantage to obtain information from both nodes.

Even though Cook et al. (1983) demonstrates that centrality is not necessarily the index of power, this study shows that degree-centrality is identified to significantly increase poor farmers' agricultural composition in their farmland. Agricultural diversification strategy

Table 34: Effect of training on the size of social networks of poorer vs richer farmers

	Only for Training Participants			All Farmers	
Variables	Number of agricultural informants who went to the same training location	Number of agricultural informants who went to the different training location	Number source of agricultural informants who did not go to the training[1]	Number of frequent agricultural information source[2]	Knowing extension agent and having frequent contact[3,4]
	(1)	(2)	(3)	(4)	(5)
Training * Post 2013 * Low Income	0.00636	0.2750	1.0850**	1.760***	0.1610
	(0.148)	(0.1800)	(0.531)	(0.619)	(0.1120)
Training * Post 2013	-0.00315	-0.397***	-0.1600	-0.8630	0.0422
	(0.113)	(0.137)	(0.404)	(0.549)	(0.0984)
Training Dummy * Low Income	0.09350	-0.2200	-2.055***	-1.0520	-0.310***
	(0.135)	(0.185)	(0.452)	(0.652)	(0.106)
Training Dummy (= 1 if Yes)				0.6330	0.137*
				(0.5240)	(0.0824)
Low Income (= 1 if Yes)				-0.4940*	0.0694
				(0.278)	(0.0492)
Year of 2013		0.2610**		-0.4450*	-0.0692
		(0.104)		(0.258)	(0.0427)
Year of 2014	-0.244***		-1.597***	-3.244***	
	(0.0857)		(0.306)	(0.260)	
Constant	0.517***	1.000***	4.767***	3.456***	0.197***
	(0.0953)	(0.130)	(0.318)	(0.253)	(0.0413)
Observations	357	357	357	899	622
Number of Household id	119	119	119	311	311
R-Squared	0.0282	0.0191	0.139	0.238	0.0123
P value of Hausman test	0.9931	0.000	0.000	0.6278	1.000

[1] *(May or may not be farmers)*
[2] *(Meet at least once every 1 or 2 days)*
[3] *(Have contact at least once every 2 weeks, = 1 if Yes)*
[4] *(Only available in 2012 and 2013)*
*Estimation is based on Random-Effects models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. Training dummy is instrumented by lottery (invitation) result.*

may be perceived differently between the richer and poorer households. Farmers who hold the most central position are usually wealthier and more educated. After the training, the richer farmers especially those with higher degree-centrality degree may find that diversification does not align with their farming strategy, thus they specialize by significantly reducing the number of crops. On the contrary, poorer farmers in general may find that diversification can provide them with much stable income. Poorer farmers with higher degree-centrality and betweenness-centrality degree are found to significantly diversify more of their crops. **After the training, richer participants with higher centrality tend to specialize while poorer participants with higher centrality appear to diversify, thus the tenth hypothesis is only partially supported.**

6.6.5 *Information Spillover from Training Participants to Non-training Participants on Agroforestry Index*

Effects of information spillover from training participants to non-training participants on agroforestry practices are exhibited in Table 37. Column 2 and 4 demonstrate that having more ties with training participants who belong to low income category are associated with significant increase in agroforestry index (by diversity) for farmers in general, while column 5 and 7 report that training participants in general even drive significant influ-

Table 35: Effect of training on the size of bridging ties between poorer and richer farmers

Variables	All Farmers			Training Participants		
	Knowing professional trainers from ICCRI[1,2]	Knowing prominent farmers in inter-island training location[1,2]	Knowing prominent farmers in intra-island training location[1,2]	Knowing professional trainers from ICCRI[1,2]	Knowing prominent farmers in inter-island training location[1,2]	Knowing prominent farmers in intra-island training location[1,2]
	(1)	(2)	(3)	(4)	(5)	(6)
Training * Post 2013 * Low Income	-0.101	-0.0697	-0.0626	-0.0707	-0.0538	-0.0626
	(0.0707)	(0.0431)	(0.0463)	(0.0909)	(0.0542)	(0.0662)
Training * Post 2013	0.440***	0.123***	0.183***	0.450***	0.123***	0.183***
	(0.0624)	(0.0382)	(0.0409)	(0.0639)	(0.0383)	(0.0465)
Training Dummy * Low Income	0.0098	0.00065	0.0000	-0.000	-0.000	0.0000
	(0.0611)	(0.0369)	(0.04000)	(0.0641)	(0.0380)	(0.0467)
Training Dummy (= 1 if Yes)	-0.0053	-0.00035	-0.000	0.000	-0.000	0.000
	(0.0274)	(0.0290)	(0.0314)	(0.04520)	(0.02670)	(0.03290)
Low Income (= 1 if Yes)	-0.00771	-0.000508	-0.0000			
	(0.0274)	(0.0166)	(0.01800)			
Year of 2013	0.0329	-0.000508	-0.000			
	(0.0274)	(0.0166)	(0.0179)			
Constant	0.00398	0.000262	0.0000			
	(0.0238)	(0.0144)	(0.01560)			
Observations	612	609	612	237	234	237
Number of Household id	311	311	311	119	119	119
R-Squared	0.307	0.0627	0.133	0.267	0.0590	0.0898
P-value of Hausman test	1.000	1.000	1.000	1.000	1.000	1.000

[1] *(= 1 if Yes)*

[2] *(Only available in 2012 and 2013)*

*Estimation is based on Random-Effects models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. Training dummy is instrumented by lottery (invitation) result.*

ence to non-training participants on agroforestry index (by category).

Training participants in general appear to successfully promote agroforestry practices to non-participants, suggesting the eleventh hypothesis to be partially supported. Poorer training participants are also found to drive spillover on all farmers in general, but not to non-training participants. Upon returning from the training, all training participants regardless of income group may have become more open-minded, thus becoming more enthusiastic to enlarge their network size by communicating more with their peers. These changes in their communication trends may lead to stronger information spillover particularly to non-training participants, stirring them to have higher chances to practice more agroforestry.

Table 36: Effects of Participants' Centrality on Agroforestry Index by Income Category

Variables	By Category	By Diversity	By Category	By Diversity	By Category	By Diversity
	(1)	(2)	(3)	(4)	(5)	(6)
Degree*Training*Post2013	-1.616**	-1.848*				
	(0.776)	(1.002)				
Degree*Training*Post2013*Poor	1.313	2.118**				
	(0.803)	(1.032)				
$\overline{\text{Degree} * \text{Training} * \text{Post2013}}$	2.005	2.485				
	(1.419)	(1.949)				
$\overline{\text{Degree} * \text{Training} * \text{Post2013} * \text{Poor}}$	-1.770	-0.815				
	(1.295)	(1.769)				
$\overline{\text{Degree Centrality}}$	-0.728	-0.475				
	(0.552)	(0.750)				
Degree Centrality	0.0237	-0.570				
	(0.378)	(0.485)				
Closeness*Training*Post2013			-0.758	-1.100		
			(0.748)	(0.989)		
Closeness*Training*Post2013*Poor			0.295	0.524		
			(0.528)	(0.648)		
$\overline{\text{Closeness} * \text{Training} * \text{Post2013}}$			0.403	0.0636		
			(1.126)	(1.575)		
$\overline{\text{Closeness} * \text{Training} * \text{Post2013} * \text{Poor}}$			0.0232	0.854		
			(0.824)	(1.109)		
$\overline{\text{Closeness Centrality}}$			-0.104	-0.147		
			(0.675)	(0.902)		
Closeness Centrality			0.114	0.0939		
			(0.337)	(0.450)		
Betweenness*Training*Post2013					-1.067	-1.811
					(1.152)	(1.503)
Betweenness*Training*Post2013*Poor					2.702	3.851*
					(1.662)	(2.157)
$\overline{\text{Betweenness} * \text{Training} * \text{Post2013}}$					1.942	4.800*
					(1.967)	(2.635)
$\overline{\text{Betweenness} * \text{Training} * \text{Post2013} * \text{Poor}}$					-4.652	-2.375
					(2.922)	(3.927)
$\overline{\text{Betweenness Centrality}}$					-0.645	-2.086
					(1.046)	(1.398)
Betweenness Centrality					-0.662	-0.891
					(0.716)	(0.933)
Training*Post2013	0.0107	0.00865	0.0977	0.269	-0.186	-0.143
	(0.222)	(0.286)	(0.410)	(0.544)	(0.181)	(0.237)
Poor (= 1 if Yes)	-0.235**	-0.402**	-0.283**	-0.484***	-0.221**	-0.329**
	(0.112)	(0.158)	(0.126)	(0.183)	(0.103)	(0.141)
Age of HH head	0.0107	0.0168	0.00910	0.0135	0.0110	0.0179
	(0.00990)	(0.0128)	(0.0101)	(0.0129)	(0.00976)	(0.0128)
Years of education of HH head	0.00108	0.0334	2.36e-05	0.0325	0.00358	0.0352
	(0.0319)	(0.0413)	(0.0328)	(0.0420)	(0.0316)	(0.0413)
ROSCA (= 1 if Yes)	0.0154	0.417	0.215	0.496	0.0960	0.498
	(0.301)	(0.426)	(0.290)	(0.422)	(0.299)	(0.410)
Log of Cultivated Farmland	0.0858	0.157	0.0858	0.136	0.0804	0.153
	(0.0852)	(0.110)	(0.0877)	(0.111)	(0.0841)	(0.110)
$\overline{\text{Age of HH Head}}$	-0.0130	-0.0118	-0.0107	-0.00561	-0.0132	-0.0119
	(0.0108)	(0.0142)	(0.0111)	(0.0145)	(0.0107)	(0.0141)
$\overline{\text{Years of Education of HH Head}}$	-0.0143	-0.0335	-0.0184	-0.0327	-0.0178	-0.0317
	(0.0353)	(0.0465)	(0.0363)	(0.0477)	(0.0350)	(0.0462)
$\overline{\text{Log of Cultivated Farmland}}$	0.188*	0.358**	0.197*	0.373**	0.196*	0.371**
	(0.113)	(0.152)	(0.119)	(0.161)	(0.113)	(0.151)
Constant	2.752***	2.909***	2.392***	2.440***	2.544***	2.632***
	(0.446)	(0.631)	(0.496)	(0.705)	(0.420)	(0.576)
Observations	688	688	646	646	688	688
Number of hhid	294	294	279	279	294	294
R-squared	0.123	0.143	0.117	0.130	0.126	0.156

*Estimation is based on Correlated Random Effects Instrumental Variable model. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5%, and 10% level, respectively. All training dummy variables are instrumented by all lottery (invitation) result variables. Year Dummy and its mean variables are included but not reported for brevity.*

Table 37: Information spillover from training participants to non-training participants by income group

Variables	All Farmers				Non Training Participants			
	Index By Category	Index By Diversity	Index By Category	Index By Diversity	Index By Category	Index By Diversity	Index By Category	Index By Diversity
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
No of Information Source who are Training Participants * Post2013	0.0150	0.0490	0.0140	0.0480	0.0260**	0.0170	0.0250*	0.0154
	(0.0104)	(0.0479)	(0.0105)	(0.0483)	(0.0132)	(0.0576)	(0.0134)	(0.0584)
No of Information Source who are Training Participants	-0.0130*	-0.0404	-0.00929	-0.0477	-0.0189**	-0.0255	-0.0140	-0.0299
	(0.00778)	(0.0375)	(0.00811)	(0.0386)	(0.00924)	(0.0420)	(0.00970)	(0.0437)
No of Information Source who are Training Participants and Belong to Low Income Category * Post 2013	-0.00881	0.115*	-0.00909	0.119**	-0.00867	0.0985	-0.00810	0.0998
	(0.0131)	(0.0594)	(0.0132)	(0.0597)	(0.0157)	(0.0667)	(0.0158)	(0.0675)
No of Information Source who are Training Participants and Belong to Low Income Category	0.0117	-0.00977	0.00942	-0.0124	0.00763	0.0134	0.00695	-0.00232
	(0.0105)	(0.0500)	(0.0106)	(0.0506)	(0.0125)	(0.0567)	(0.0126)	(0.0574)
Training * Post 2013 * Low Income	0.0321	-0.239	0.0307	-0.233				
	(0.0441)	(0.192)	(0.0441)	(0.193)				
Training * Low Income (1 = Yes)	-0.0401	0.558***	-0.0491	0.585***				
	(0.0386)	(0.214)	(0.0389)	(0.215)				
Training * Post 2013	-0.0605*	0.145	-0.0582	0.150				
	(0.0356)	(0.154)	(0.0356)	(0.155)				
Training (1 = Yes)	0.0633**	-0.402**	0.0668**	-0.433***				
	(0.0307)	(0.165)	(0.0308)	(0.166)				
Low Income (1 = Yes)	0.000734	-0.262**	0.0113	-0.308***	-0.00243	-0.148	0.00838	-0.178
	(0.0177)	(0.110)	(0.0182)	(0.112)	(0.0204)	(0.112)	(0.0208)	(0.113)
Year of 2013	0.0210	-0.140	0.0231	-0.141	0.00590	-0.0348	0.00971	-0.0288
	(0.0198)	(0.0888)	(0.0200)	(0.0898)	(0.0226)	(0.0962)	(0.0228)	(0.0977)
Year of 2014	0.0269	-0.326***	0.0278	-0.323***	0.00357	-0.222**	0.00393	-0.210**
	(0.0188)	(0.0835)	(0.0188)	(0.0842)	(0.0211)	(0.0894)	(0.0212)	(0.0904)
Constant	0.0227	-0.0166	0.0176	0.339	0.0808	-0.424	0.106*	-0.00469
	(0.0429)	(0.242)	(0.0514)	(0.295)	(0.0531)	(0.277)	(0.0642)	(0.339)
Category Dummy	YES	YES	YES	YES	YES	YES	YES	YES
Village Fixed-Effects	NO	NO	YES	YES	NO	NO	YES	YES
Observations	899	899	898	898	549	549	548	548
Number of hhid	311	311	310	310	192	192	191	191
R-squared	0.101	0.0930	0.154	0.144	0.0993	0.0921	0.171	0.147
P-value of Hausman test	0.7388	0.8654	0.8437	0.9111	0.3834	0.7233	0.5980	0.7556

*Estimation is based on Random-Effects Instrumental Variable models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result. No of information sources who are training participants are instrumented with no of information sources who are selected to participate according to lottery result. Age and years of education of household head as well as cultivated farmland (in Log) are included but not reported for brevity.*

6.6.6 *Effects of Agroforestry upon Income Smoothing*

Farmers' average produce sold annually is reported in Table 38. Evidence is found that after the training, poorer training participants have significantly increased their production of leguminous and industrial crops (column 2 and 3). I later confirmed with the income report in Table 39, which shows that poorer farmers indeed have increased their income for leguminous crops (column 3) and even their total farm income in general (column 1). This is contrast with training participants in general who reported a decline in income for the same commodity. It could possibly that higher-income training participants have stopped cultivating leguminous crops but done more intensification of other crops instead.

Table 38: Effects of training on agricultural produce sold (in Kg)

Variables	Log of Produce Sold						
	(1) Cereal Crops	(2) Leguminous Crops	(3) Industrial Crops	(4) Spice Crops	(5) Vegetable Crops	(6) Fruit Crops	(7) Hardwood
Training * Post 2013 * Low Income	0.613	0.436*	0.814*	-0.0173	0.0729	1.020	0.0867
	(0.429)	(0.236)	(0.488)	(0.501)	(0.196)	(0.629)	(0.120)
Training * Post 2013	-0.561	-0.641***	-0.997**	0.0633	0.0165	-0.908	-0.0219
	(0.379)	(0.209)	(0.432)	(0.443)	(0.174)	(0.557)	(0.106)
Training Dummy * Low Income	-0.497	-0.261	-0.0442	0.260	-0.0194	-1.251	-0.00276
	(0.460)	(0.246)	(0.553)	(0.563)	(0.212)	(0.778)	(0.114)
Training Dummy (= 1 if Yes)	-0.170	0.465**	0.377	-0.257	0.204	1.227**	0.00519
	(0.367)	(0.197)	(0.438)	(0.447)	(0.169)	(0.610)	(0.0925)
Low Income (= 1 if Yes)	-0.0893	-0.0801	-1.375***	-1.213***	0.0122	-1.159***	0.00517
	(0.202)	(0.105)	(0.250)	(0.254)	(0.0935)	(0.366)	(0.0452)
Year of 2013	0.138	-0.0759	0.267	0.617***	-0.00190	2.089***	0.104**
	(0.179)	(0.0986)	(0.204)	(0.209)	(0.0820)	(0.263)	(0.0500)
Year of 2014	-0.0267	-0.0324	-0.154	-0.314	-0.0823	2.208***	0.00660
	(0.179)	(0.0983)	(0.203)	(0.209)	(0.0817)	(0.262)	(0.0498)
Constant	0.405	0.0637	6.500***	2.195***	0.207	3.775***	0.0255
	(0.318)	(0.167)	(0.390)	(0.396)	(0.147)	(0.565)	(0.0734)
Village Fixed Effects	YES	YES	YES	YES	YES	YES	YES
Observations	926	926	926	926	926	926	926
Number of Household id	311	311	311	311	311	311	311
R-squared	0.103	0.0580	0.150	0.213	0.0223	0.255	0.0317
P-value of Hausman test	0.9993	0.0039	0.8167	0.9106	0.9953	0.1892	0.9980

*Estimation is based on Random-Effects models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result. Village dummies are not shown for brevity.*

Table 40 examines the correlation of agroforestry on income vulnerability. Column 1 to 8 show that crop diversification has significantly negative association on farm income variation. This indicates that for each addition of commodity, the income variation becomes smaller. However, as agroforestry variables are used in the previous sections as a dependent variable, it may be endogenous. A dummy on agroforestry is constructed as having cultivated more than 1 crop in the farmland, which still shows strong negative effects on income variance.

The income report shows that diversification is relevant to help poorer farmers stabilize their farm income, which is consistent with the twelveth hypothesis. In the previous sections evidences are found that poorer training participants tend to keep the number of crop category or increase the crop diversity after returning from training. Deeper examinations discover that the poor may have significantly produced more of legume and industrial crops, and they also significantly increase their farm income post-training relative to the rich. With less diversity, the income decreased for the

Table 39: Effects of training on income from different commodities

Variables	Log of Income							
	(1) Total Farm Income	(2) Cereal Crops	(3) Leguminous Crops	(4) Industrial Crops	(5) Spice Crops	(6) Vegetable Crops	(7) Fruit Crops	(8) Hardwood
Training * Post 2013 * Low Income	1.307***	1.229	1.360**	0.598	-1.439	0.130	1.803	0.269
	(0.245)	(0.925)	(0.610)	(1.039)	(1.520)	(0.393)	(1.208)	(0.415)
Training * Post 2013	-0.695***	-1.169	-1.726***	-0.859	1.674	0.0113	-1.287	-0.206
	(0.28)	(0.818)	(0.540)	(0.919)	(1.344)	(0.347)	(1.068)	(0.367)
Training Dummy * Low Income	-1.033***	-1.149	-0.817	0.820	1.397	-0.0199	-1.810	-0.0986
	(0.266)	(1.014)	(0.649)	(1.243)	(1.797)	(0.421)	(1.492)	(0.393)
Training Dummy (= 1 if Yes)	0.576***	-0.443	1.400***	0.344	-1.144	0.417	1.903	-0.0559
	(0.211)	(0.807)	(0.519)	(0.979)	(1.417)	(0.337)	(1.170)	(0.320)
Low Income (= 1 if Yes)	-1.056***	0.0173	-0.215	-2.564***	-3.292***	0.0243	-2.146***	0.0985
	(0.120)	(0.450)	(0.283)	(0.577)	(0.830)	(0.185)	(0.702)	(0.157)
Year of 2013	-0.104	0.401	-0.178	-0.436	1.686***	-0.00949	3.508***	0.394**
	(0.103)	(0.386)	(0.255)	(0.434)	(0.635)	(0.164)	(0.505)	(0.173)
Year of 2014	-0.0730	-0.0424	-0.213	-0.222	0.596	-0.166	3.943***	0.0887
	(0.106)	(0.385)	(0.254)	(0.433)	(0.633)	(0.164)	(0.503)	(0.173)
Constant	16.73***	0.495	0.166	16.69***	6.305***	0.413	8.075***	0.0249
	(0.183)	(0.706)	(0.446)	(0.894)	(1.287)	(0.291)	(1.084)	(0.254)
Village Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Observations	853	926	926	926	926	926	926	926
Number of Household id	309	311	311	311	311	311	311	311
R-squared	0.325	0.110	0.0722	0.125	0.152	0.0216	0.248	0.0239
Hausman test	0.0002	0.8641	0.0363	0.9786	0.9965	0.0040	0.2670	0.9954

*Estimation is based on Random-Effects Instrumental Variable models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result. Village dummies are not shown for brevity.*

rich while it increases for the poor, because: (1) Crop specialization takes longer to grow, (2) As the poor kept number of crops relative to the rich, the poor may have benefited from lower supply in the market in the short term.

This section concludes that agroforestry is found to be relevant for the poorer households to increase their farm income and stabilize their earnings, and training is an appropriate strategy to spread awareness regarding agroforestry practices.

6.7 DISCUSSIONS AND POLICY IMPLICATIONS

This chapter aims to investigate the impact of institutionalized training on the adoption and perceived benefits of agroforestry practices particularly differentiating between the poorer and higher income farmers. To see the adoption mechanism, various social network ties amongst training participants as well as interaction with peers and experts resulting from the training are examined. Farmers' structural properties in their local farming community is also incorporated in the analysis, in addition to the training spillover from participants to non-participants upon returning from the training. The highlights of this chapter are as follow:

First, different attitudes on agroforestry are identified between poorer and richer training participants. Richer training participants in general are found to reduce their number of crops in their farmland upon returning from the training, in contrast to their poorer counterparts who increase crop diversity or keep crop category. Training participants coming from below-median farm income are probably the most benefited from the agroforestry training program, because agroforestry practices help stabilize their income. The results suggest that the poor tend to be more diversified in terms of crop di-

Table 40: Effects of agroforestry on farm income Coefficient of Variation (CV)

	CV of Farm Income				Log of CV of Farm Income			
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Agroforestry Index	-3.861***		-3.001**		-0.156***		-0.132***	
	(1.237)		(1.273)		(0.0463)		(0.0479)	
Agroforestry Dummy (= 1 if having more than 1 crop type)		-11.66***		-8.495**		-0.401**		-0.287*
		(3.934)		(4.028)		(0.163)		(0.166)
Year of 2012	-1.096	-2.227	0.547	-0.158	-0.0367	-0.0712	0.0115	-0.00582
	(2.905)	(2.899)	(2.998)	(3.022)	(0.108)	(0.104)	(0.112)	(0.108)
Year of 2013	1.527	0.340	1.707	0.836	0.0585	0.00965	0.0414	0.00178
	(2.932)	(2.918)	(3.026)	(3.006)	(0.109)	(0.109)	(0.114)	(0.112)
Age of Household Head			0.364***	0.376***			0.00673	0.00719
			(0.131)	(0.131)			(0.00493)	(0.00574)
Years of Education of Household Head			-0.288	-0.279			0.00940	0.00977
			(0.414)	(0.393)			(0.0155)	(0.0152)
Log of Cattle Value			0.193	0.170			0.00407	0.00298
			(0.207)	(0.207)			(0.00780)	(0.00700)
Household Member			-3.363***	-3.339***			-0.116***	-0.116***
			(0.952)	(0.968)			(0.0360)	(0.0363)
Native[1]			-3.833	-3.312			-0.161	-0.148
			(5.332)	(5.817)			(0.199)	(0.178)
Second Generation Migrant[1]			-0.926	-0.665			-0.0441	-0.0371
			(3.014)	(2.941)			(0.113)	(0.105)
Constant	80.52***	82.31***	75.24***	75.41***	1.608***	1.612***	1.570***	1.504***
	(5.880)	(6.341)	(11.40)	(11.45)	(0.219)	(0.262)	(0.427)	(0.509)
Village Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Observations	909	909	865	865	903	903	859	859
R-squared	0.110	0.111	0.137	0.137	0.068	0.066	0.081	0.078

[1] *(= 1 if Yes)*

*Results are based on Pooled-OLS estimation. Robust standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*

versity or tend to keep the crop category in their limited farmland. Post-training, poorer farmers may think that cultivating main cash crop is not sufficient, because: (1) crops are harvested after several months; (2) yields may not be as high due to limited land size and intensive management required; and (3) market uncertainty. Poorer farmers may look for options to diversify their cropping systems and to increase incomes, and training has helped them to achieve the objectives. This finding may challenge Grannall (1995) who posits that low-educated farmers may feel threaten by formal training.

On contrary, general training participants may learn from the training that the commodities they had in the farmland are not suitable environmentally and financially, thus reducing crop diversity or replace it with other commodities. Some with relatively larger farmland may opt to concentrate on main cash-crops instead due to some considerations they weigh from the training.

The results may also indicate that larger farms are generally more diversified than smaller farms to begin with (see Culas and Mahendrarajah, 2005), but the training has probably helped the poorer to achieve the optimum level of diversification to protect them from risks. They may find the right recommendation and knowledge from the training thus implemented the techniques in their farmland upon returning from the training.

Second, perceived merits of agroforestry may differ between richer and poorer farmers; the former tends to see its environmental benefits while the latter emphasizes on economic merits. While higher income farmers tend to reduce crop diversification after the training (in contrast to lower income farmers), they still testify agroforestry benefits despite reducing it. The results found that richer farmers may have confirmed the ecological benefits that are both theoretical and technical, while poorer farmers may have confirmed the economic benefit that is practical. From a policy point of view, agriculture technology adoption for the poor may be advisable to emphasize the economic gains more than the environmental merits

Third, the change in the poor's attitude on farming practices may be primarily driven by the increase in their size and depth of social network ties. The poorer trained farmers may have stronger motivation than the average training participants in general, as they tend to increase communication frequency with their peers, except with fellow farmers who went to the training. This significant increase in their depth and size of network may have propelled adoption of crop diversity. The finding is in line with Kilpatrick and Rosenblatt (1998), who posit that farmers who solicit information from peers tend to belong to lower socio-economic status and smaller farms. Burkhardt (1994) argues that the individuals with whom a person interacts directly influence beliefs about personal mastery, but attitudes and behaviors are more affected by structurally equivalent co-workers. In this case, interaction with peers may potentially be a stronger driver to perform more diversification. However, richer participants behave differently, as they tend to limit information exchange with their network upon returning from the training, because they tend to value new information more than the poor.

Fourth, poorer training participants who are influential in their locale, or being in the "central" position tend to diversify more upon returning from the training. This indicates the possibility that agroforestry may be aligned with the poor farm management strategy as their smaller farmland size encourages them to diversify for more stable income. However, I found that is not the case for the richer training participants, as the more influential people tend to specialize because they are endowed with much larger farms. Poorer training participants with higher centrality scores may have obtained strong influence from their network that enables them to finally adopt agroforestry practices. That reinforcement, altogether with the correct knowledge they obtain from the training may have helped them to consider more diversification in their farmland.

Fifth, all training participants in general are found to significantly diffuse knowledge regarding agroforestry practices to non-training participants. The training experience may have stimulated them to be more enthusiastic in knowledge gathering activities with their peers, thus positively influencing their non-trained counterparts to practice more diversification. Spillover from poorer training participants to all farmers in general is also identified. Poorer training participants who often lack the opportunity to access formal training may also have experienced significant changes in their attitudes related to farming and even personal development.

Sixth, with less diversity, the income decreased for the rich while it increases for the poor, particularly for leguminous crops. This is because: (1) Crop specialization takes longer to grow; (2) As the poor kept diversity relative to the rich, the poor may have benefited from lower supply in the market, significantly increasing their farm income in the short term. Leguminous trees complement and increase farm profit level, and are probably the most efficient in terms of cost-benefit, to be adopted by poor farmers. More evidence are found that poorer training participants tend to produce more of leguminous and industrial crops (probably as a strategy to stabilize their income), resulting in significant upsurge in their aggregate farm income. Dercon and Krishnan (1996) found that in Tanzania and Ethiopia, the poor typically enter into activities with low entry costs for income smoothing. In the context of Indonesian rural households, leguminous and industrial crops may be perceived as low cost and risk, but with decent returns. Legume and industrial crops can serve as food, shades trees, while providing beneficial environmental benefits at the same time, hence preferred by poorer farmers. Future development programs on sustainability should consider variation to distinguish farmers according to socio-economic characteristics while using low-cost, community-based dissemination approaches.

All in all, diversification may advance household welfare particularly for low income farmers, as it helps to reduce income vulnerabilities. However, agroforestry examined in this chapter may not generate a reduced deforestation, as I have limitation in incorporating ecological and biophysical criteria of the surveyed sample. I also believe many excesses following agroforestry adoption that affect income remains uncaptured in this study, amongst them are the provision of fodder, fuelwood, and medicinal purposes that are difficult to appraise monetarily. These provisions, which also could be obtained from leguminous produce, can diversify farmers' farm income thus reducing vulnerabilities.

7 CONCLUSION

7.1 SUMMARY OF FINDINGS

This dissertation tries to address the missing links between the role of formal extension services in the form of institutionalized training and informal social network in the form of rural network with peers and neighbors upon information dissemination and technology adoption. The primary objective of this dissertation is to provide experimental evidence that exposing randomly selected farmers to institutionalized agricultural training can elevate agricultural knowledge as well as promote technology adoption due to the strengthened social network resulting from the training experience. To serve the purpose, social experiment is carried out with different training environments that can generate different learning experience. These experiences can hypothetically be reflected in the diffusion and adoption behavior. The study context of Indonesian rural households and the details of the experiment has been explained in Chapter III; while three empirical studies stemmed from the experiments have been explored in Chapter IV to VI.

Chapter IV elucidates several findings, that network ties to agricultural informants and network structures within farmers' local neighborhood might determine farmers' ability for information gathering. In this chapter I examine the role of various network ties, including friendship network and advice network, upon farmers' knowledge acquisition ability during formal agricultural training. I also examine how farmers' position in their local network structures influence their knowledge gathering skill. I found that the numbers of ties positively contributes to knowledge acquisition to some extent; and that farmers who occupy a central position in their network structures in the neighborhood show better learning outcomes. This is an indication that one's position in their local network may be very important in driving learning outcomes than simply having more ties.

Chapter V provides the evidence of the role of institutionalized training in strengthening farmers' network, which tend to be reflected in farmers' technology adoption. I administered institutionalized training in varying locations (in farmers' hometown and in remote locations comprise intra-island and inter-island locations) to investigate the effect of social learning on agricultural technology adoption. Regardless of the locations, participants received the same training. The chapter highlights that the training may have helped to increase knowledge of better farming practices and that training held in an inter-island location may have significantly spurred the adoption of water-conservation techniques. I also found that farmers trained in an inter-island location tend to communicate more frequently with their peers and experts upon returning from training, which induces their propensity to adopt the technology. Farmers' centrality properties are found to have influenced their knowledge gathering ability especially for the complex agricultural training. The chapter concludes that training spillover from participants to non-participants is likely to be detected, resulting in the diffusion of agricultural techniques even though it has yet to propel adoption for the non-participants.

Chapter VI examines the effectiveness of institutionalized agricultural training in promoting agroforestry to reduce income vulnerabilities. Here I distinguished between poorer and higher income farmers to see agroforestry system's relevance to the poor, their ability to adopt, and the ultimate economic outcomes of adoption. I found that after the training, the poorer farmers tend to keep their number of crops or diversify, which is significantly contributed by leguminous and industrial crops. After the training, the poor are also likely to increase the depth and size of social network with their peers and agricultural specialists. Training spillover is also significantly stronger for the poorer participants compared to their richer counterparts. Impact evaluation assessments also show that crop diversification appears to be negatively associated with income vulnerabilities, indicating the program's relevance and benefits for poverty reduction.

This whole dissertation provides an evidence, that at the beginning, formal institutions, be it agricultural training such as the one studied in this research or institutionalized extension services, may play important roles to raise awareness regarding agricultural practices. Nevertheless, for a faster dissemination strategy, informal social network may help hasten the information diffusion amongst farmers. As new technologies need encouragements from many parties in order to be fully embraced by the society, informal rural network serves as the primary enforcer for technology adoption.

Deeper analysis also show that not only training has helped farmers to broaden their knowledge and advance their farming practices, it is also found to have developed farmers' capacity both at personal-level and community-level. Upon returning from the training, trained farmers are observed to become more enthusiastic in information gathering, as well as play active part in their community as indicated by the stronger network centrality measures.

7.2 LIMITATION OF THIS STUDY

Randomized trials do two things that are very rare among other designs: if conducted rigorously, they yield an estimate of the effect that is unbiased and consistent (Shadish et al., 2008; Mackenzie and Grossman, 2005). The strength of the RCT rests on its excellent internal validity, which is based largely on the power of randomisation to ensure that the only difference between two treatment groups is their exposure to the treatment of interest (Booth and Tannock, 2014).

While much attention has been drawn to the assessment and reporting of the internal validity of trials, less attention is given to their external validity. Criticism on RCTs routinely involves its limitation on external validity, or generalizability when implemented in other treatment setting. In order to be generally useful, the result of a trial must also be relevant to universal practice, i.e. be reasonably likely to be replicated when applied to a definable group of people in a particular treatment setting.

RCT conducted in this study may be internally valid in the context of rural Indonesian households, as it involves rigorous analysis to control for bias with considerable number of observation as well as the availability of panel data. Even though it may be possible to replicate this trial design elsewhere, the intervention may not necessarily yield the same result if conducted in other population. Interventions such as the ones conducted in this study tend to interact with many factors as cultural, socio-economical, and geographical level which may be different across population.

7.3 POLICY RECOMMENDATIONS

Finally, I present several policy recommendations that are loosely based on the main findings of this dissertation. The results of these studies are expected to attract the attention of professionals and policymakers who are interested in program designs and implementation promoting agricultural technology in the developing countries and who may want to consider the effects of social interaction and social capital as key determinants for innovation dissemination. For scholars, these studies can serve as additional evidence to prove the importance of social interactions in modelling the complexity of diffusion of innovation phenomena.

1. **Institutionalized training directed to smallholders-farmers could be a cost-effective measure to disseminate agricultural information and propel technology adoption to some extent**
   Depending on the complexity of agricultural techniques, training may be able to successfully promote the adoption of technology within the short or medium timeline. Agricultural training is not necessarily be resource- and cost-intensive like Farmers Field School or Training and Visit Extension, but the knowledge or information disseminated should be very specific and highly relevant to farmers. The potential benefits of technology should also be communicated to the potential adopters, as farmers may not be willing to embrace it entirely due to uncertainty, risk, and costs that are attached to it. Furthermore, for the adoption to be embraced quickly, the merits and benefits that come from implementation of such technology should also possibly be experienced within the short or medium timeline –which is another challenge for promotion of technology adoption.

2. **Agricultural training should put more emphasis on knowledge facilitation and diffusion amongst participants and consider the potential spillover to non-training participants.**
   Interaction with multiple sources may be required to 'prompt' change in farmers' mindset and practices, and emotional connections may be necessary for change to occur (Kilpatrick, 2002). Farmers who solicit information from peers tend to belong to lower socio-economic status and smaller farms (Kilpatrick and Rosenblatt, 1998), while farmers with higher level of formal education are more likely to participate in further training and interact more with experts (Kilpatrick, 1996). For agricultural training to be successful, interaction with peers and experts should be encouraged as that may cause positive spillover upon knowledge transfer (Tessmer and Richey, 1997). Also, farmers will seem to work harder and more motivated when they work with friends who were more diligent than themselves (Kato and Shu, 2008), and the presence of friends might generate contagious enthusiasm or incentives to compete (Katz and Earl, 2010).

3. **Agricultural training or participatory workshop should provide special provision in the program to enable participants to interact with each other, discuss, and exchange ideas i.e. networking session.**
   In the context of participatory workshop or agricultural training, social learning could be triggered when different stakeholders meet and engage with one another during program activities, and occurs when a change is manifested within the dimensions of those in attendance at the session (Muro and Jeffrey, 2008; Reed et al.,

2010). While innovation adoption behavior requires reinforcement from multiple parties in the household (Centola, 2010), interaction with multiple sources may also be required to 'prompt' change in farmers' mindset and practices. Emotional connections may also be necessary for change to occur (Kilpatrick, 2002). Future training program should be advisable to incorporate a special interactive session for the exchange of ideas amongst participants to be able to get to know each other personally.

4. **Conducive learning environment during agricultural training should not be neglected, and this can emerge through engaging programs involving field trips to more advanced places.**
Studies on varying learning environment, especially involving farmers' field-trips are not much explored. Results from this study indicates that study trip to more advanced location which are relevant to the training content is found to improve motivation (Ricci and Holland, 1992; Hong et al., 1995), which will eventually affect farmers' attitudes to improve current practices. Field trip features embedded in remote-location training can motivate participants (Shinew and Backman, 1995). Training motivation theory postulates that motivation to learn has a direct effect on learning outcomes, which includes affective (i.e. satisfaction indicators) and cognitive outcomes (knowledge) (Colquitt et al., 2000). Even though further research may be needed to examine linkages between learning environment, knowledge acquisition, and satisfaction indicators, designing training programs with study trips incorporated can be one way to gauge participants' internal and external motivation. Study trips may not necessarily be in the most remote location, as visit to different district or to the nearest more developed places may be sufficient to improve training experience.

5. **Government and extension agencies should undertake more efforts to involve farmers as much as possible in formal or informal activities to stimulate them to adopt sustainable farming practices.**
Evidence provided by the study suggests that persuasion, social influence, and competition are significant influences in the decisions of farmers. Local government should periodically conduct a competition across villages regarding better farming practices that are initially introduced by extension services. As farming group prevails in disseminating knowledge within the neighborhood, competition should encourage collaboration and cooperation amongst members and even across different farmers group. Incentives should be given to those groups who succeed to work in collaboration with others.

6. **Government may have to push more "affirmative actions" especially targeting farmers with below-median farm income category for poverty eradication strategy.**
As most existing government intervention program is participatory in nature, there is a need to identify the poorest of the intended program target to encourage poverty eradication in many forms. Future development programs, especially on sustainability should consider variation to distinguish farmers according to socio-economic characteristics while using low-cost, community-based dissemination approaches. As perceived benefits are an initial pre-requisite for potential adoption, economic benefits should be emphasized for these target groups.

7. **For more effective information dissemination strategy, future development program may be advised to approach more influential people in the community.** People who tend to occupy the central position in the community appear to be more influential and popular. Their voice tend to be heard and considered by the people inside their community. For future programs to promote knowledge and adoption, selecting few contact farmers to help spread the information and adoption are advisable for more cost-effective dissemination strategy in the rural area.

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Part I

APPENDIX

A

ADDITIONAL ANALYSIS

A.1 EFFECTS OF TRAINING ON CENTRALITY MEASURES

A.1.1 *Overview*

Institutionalized agricultural training is found to have altered farmers' communication patterns both within their local community and in their personal-level, as indicated in Chapter 5 and Chapter 6. Changes are manifested both in terms of size and depth of farmers' social network. This additional part aims to see whether such effects present in shaping farmers' structural position in their local community.

Upon returning from the training program, participants are presumed to be more knowledgeable and experienced relative to their non-participating peers. These knowledge improvement may have transformed the way training participants are regarded in their local community. Training participants may have become more influential after the training.

As centrality measures have been used as independent variables in the previous regression analysis, this section intends to employ centrality as dependent variables.

A.1.2 *Estimation Strategy*

To examine the effects of agricultural training on network centrality, two models are employed. Both incorporate location-heterogeneity effects as well as income-factors. These models are as follow:

1. Effects of Training on Centrality Measures (with Location Heterogeneity)

$$Centrality_{i,t} = \alpha + \beta_1 Training_{i,t} * Post2013 + \beta_2 Training_{i,t} * Post2013 * Location_l + \beta_3 Post2013 + \beta_4 Training_{i,t} + \beta_5 Training_{i,t} * Location_l + u_i + w_{i,t}$$

where i is the household head in year t. In Estimation 1, the dependent variable is various centrality measures, consist of out-degree centrality, out-closeness centrality, and betweenness centrality. The independent variable is the interaction term between the training participation dummy and the year of post-2013, which aims to reveal the post-training effects on centrality, and the interaction term of the training participation dummy, the year of post-2013 and location l dummy (hometown, intra-island, and inter-island), whose purpose is to examine the impact of location heterogeneity.

2. Effects of Training on Centrality Measures (according to Income Category)

$$Centrality_{i,t} = \alpha + \beta_1 T_{i,t} * Y + \beta_2 T_{i,t} + \beta_3 T_{i,t} * Y * LowIncome + \beta_4 T_{i,t} * LowIncome + \beta_5 LowIncome + \beta_6 Y + u_i + w_{i,t}$$

where i is the household head in year t. In Estimation 2, similarly with Estimation 1, the dependent variable is various centrality measures, namely out-degree centrality, out-closeness centrality, and betweenness centrality. The independent variable is the interaction term between the training participation dummy (T) and the year of post-2013 (Y), to see the post-training effects upon centrality. I also construct the same interaction term for poorer farmers ($LowIncome$), to observe whether poorer trained participants behave differently.

A.1.3 *Result*

1. Effects of Training on Centrality Measures (with Location Heterogeneity)

Table 41 exhibits training effects upon various centrality measures. Column 2 indicates that when location heterogeneity is taking into account, training participants are more likely to increase their degree-centrality scores upon returning from the training. Moreover, column 5 and 6 show that training participants are more likely to increase their betweenness centrality scores upon returning, suggesting that they may have become the bridge of information (or gatekeeper of knowledge) within their local community. An individual with high betweenness centrality have a large influence on the transfer of items through the network. One of major findings of this research is that agricultural training is found to primarily increase participants' knowledge. This result provides another evidence that the increase in network has led to better structural position in farmers' local community. Training does not necessarily make one more influential in their farming community, but enables one to become the bridge of knowledge transfer in the community.

Table 41: The effects of training on centrality measures

Variables	Out-degree Centrality		Out-closeness Centrality		Betweenness Centrality	
	(1)	(2)	(3)	(4)	(5)	(6)
Training * Post 2013	0.0222	0.0753**	-0.0380	0.0541	0.0326**	0.0399*
	(0.0232)	(0.0319)	(0.158)	(0.218)	(0.0150)	(0.0206)
Training (1 = Yes)	0.0244	-0.0158	-0.0485	-0.0989	0.00178	0.00517
	(0.0243)	(0.0347)	(0.137)	(0.194)	(0.0154)	(0.0219)
Training * Post 2013 * Intra-island		-0.116***		-0.16800		-0.0287
		(0.0404)		(0.27800)		(0.0261)
Training*Post 2013*Inter-island		-0.04950		-0.1130		0.00522
		(0.0390)		(0.26600)		(0.0252)
Intra-island Training (1 = Yes)		0.0721*		0.0726		-0.00268
		(0.0438)		(0.249)		(0.0277)
Inter-island Training (1 = Yes)		0.0514		0.0806		-0.00714
		(0.0426)		(0.238)		(0.0269)
Year of 2013	-0.0544***	-0.0543***	-0.000835	-0.00181	-0.00805	-0.00802
	(0.0142)	(0.0142)	(0.0950)	(0.0951)	(0.00918)	(0.00915)
Year of 2014	-0.105***	-0.105***	0.0629	0.0622	0.00359	0.00364
	(0.0146)	(0.0146)	(0.0978)	(0.0979)	(0.00946)	(0.00944)
Constant	0.372***	0.370***	0.585***	0.581***	0.0368*	0.0354*
	(0.0302)	(0.0307)	(0.143)	(0.145)	(0.0189)	(0.0192)
Village Dummy	YES	YES	YES	YES	YES	YES
Observations	734	734	692	692	734	734
Number of hhid	297	297	282	282	297	297
R-Squared	0.225	0.225	0.0193	0.0197	0.0901	0.0925

*Estimation is based on Random-Effects models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result.*

2. Effects of Training on Centrality Measures (by Income Group)

Evidence on the effects of training by income category on participants' structural position in their locale is shown in Table 42. Similarly, column 5 and 6 suggest that training participants in general are more likely to increase their betweenness centrality scores upon returning from the training. However, such effects are absent for participants coming from low income group, who tend to weaken their betweenness centrality power. As it takes many factors to be influential in one's local network (i.e. wealth, social status, and education), this result finds that knowledge possession may make one more centralized in the community. Training has provide a platform for its participants to increase their prominence in their local neighborhood due to increased knowledge.

Table 42: The effects of training on centrality measures (by income category)

Variables	Out-degree Centrality		Out-closeness Centrality		Betweenness Centrality	
	(1)	(2)	(3)	(4)	(5)	(6)
Training*Post 2013	0.00797	0.00901	-0.0153	-0.0328	0.0507***	0.050200***
	(0.0276)	(0.0276)	(0.193)	(0.194)	(0.0178)	(0.017900)
Training (1 = Yes)	0.00686	0.0272	0.0440	0.0663	-0.0143	-0.00136
	(0.0354)	(0.0324)	(0.182)	(0.183)	(0.0211)	(0.0207)
Training*Post 2013*Low Income	0.0381	0.0300	-0.00404	-0.00002	-0.0391*	-0.0384*
	(0.0326)	(0.0326)	(0.221)	(0.2230)	(0.0210)	(0.0211)
Training*Low Income	-0.0279	-0.0184	-0.16500	-0.22400	0.00889	0.00493
	(0.0472)	(0.0429)	(0.23200)	(0.23500)	(0.0281)	(0.0274)
Low Income (1 = Yes)	-0.0543**	-0.0664***	0.08080	0.11600	-0.0215	-0.0213
	(0.0236)	(0.0213)	(0.100)	(0.104)	(0.0138)	(0.0135)
Year of 2013	-0.0535***	-0.0536***	-0.00640	-0.00331	-0.00890	-0.00771
	(0.0141)	(0.0141)	(0.0939)	(0.0950)	(0.00907)	(0.00914)
Year of 2014	-0.104***	-0.105***	0.0578	0.0606	0.00401	0.00380
	(0.0146)	(0.0146)	(0.0969)	(0.0978)	(0.00938)	(0.00942)
Constant	0.330***	0.408***	0.537***	0.516***	0.0760***	0.0476**
	(0.0190)	(0.0319)	(0.0913)	(0.156)	(0.0113)	(0.0202)
Village Dummy	NO	YES	NO	YES	NO	YES
Observations	736	734	694	692	736	734
Number of hhid	297	297	282	282	297	297
R-Squared	0.0798	0.261	0.00233	0.0208	0.0303	0.112

*Estimation is based on Random-Effects models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. All training dummy is instrumented by all lottery (invitation) result.*

A.2 INFORMATION FLOWS ACROSS FARMERS GROUP

A.2.1 *Overview*

This part seeks to understand how information and knowledge transfer across farmers group. In this research, amongst the existing 36 farmers group, I only examined 16 farmers groups which become the main object of the analysis. In 2014, a question is administered to the leader of the farmers group, whether they know any of the members coming from the different group. "Knowing" should be mutual, so if they mention they know a member of other group, that person should have known them too. Interviewer prompt each of the group's name, village name, as well as the group leader's name to obtain personal network of the group leader. The answer from the group leader serves as the representative of the group's network coverage. Unfortunately this data only covers 2014 time period (or one year after the training), making the training effect difficult to estimate.

A.2.2 *Relationship Across Farmers Groups*

Figure 14 depicts the ties across groups, showing the directions of communication (in arrows), while figure 15 present ties in circled network. The group name starting with "1" indicates that they are located in Sumberejo sub-district, while those starting with "2" specifies that they belong to Pulau Panggung sub-district.

Figure 14 and Figure 15 shows that group no. 11, 25, and 27 know at least one member from all of the group, showing that these groups may be influential and becoming the main information source amongst all farmers groups observed in the study area.

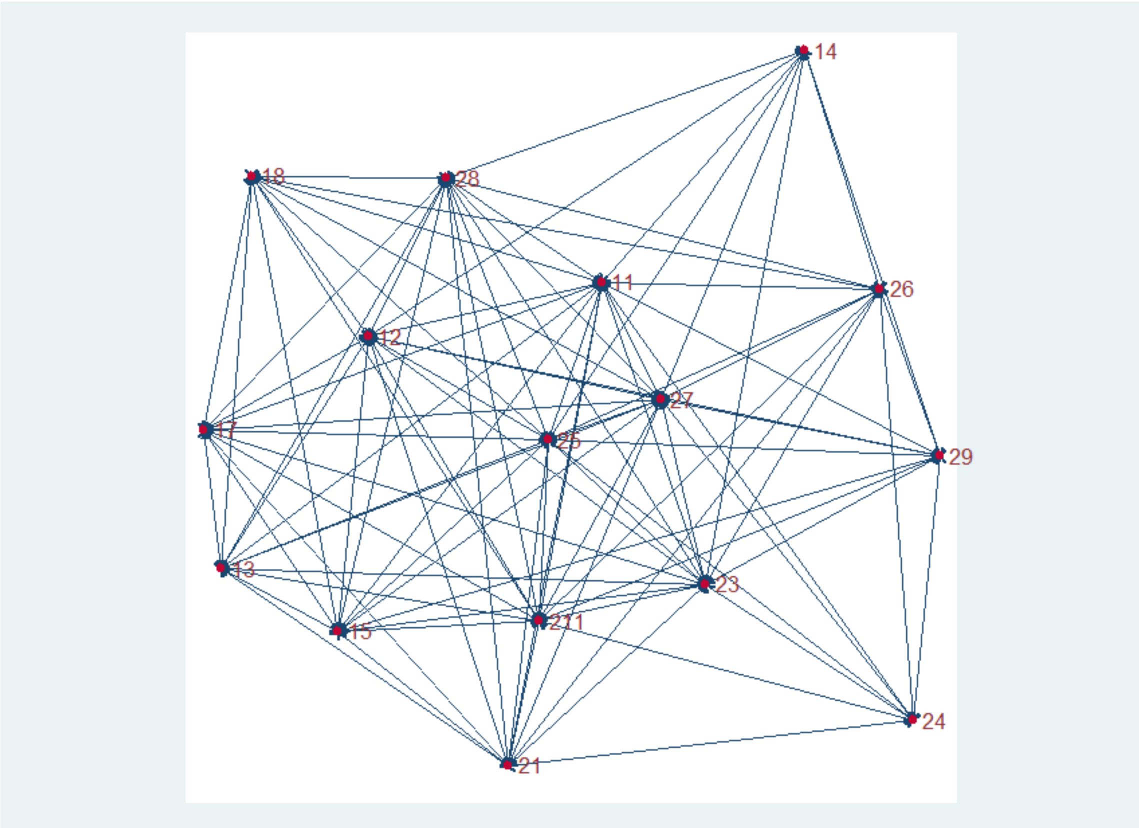


Figure 14: Network ties across all farmers groups (with arrows)

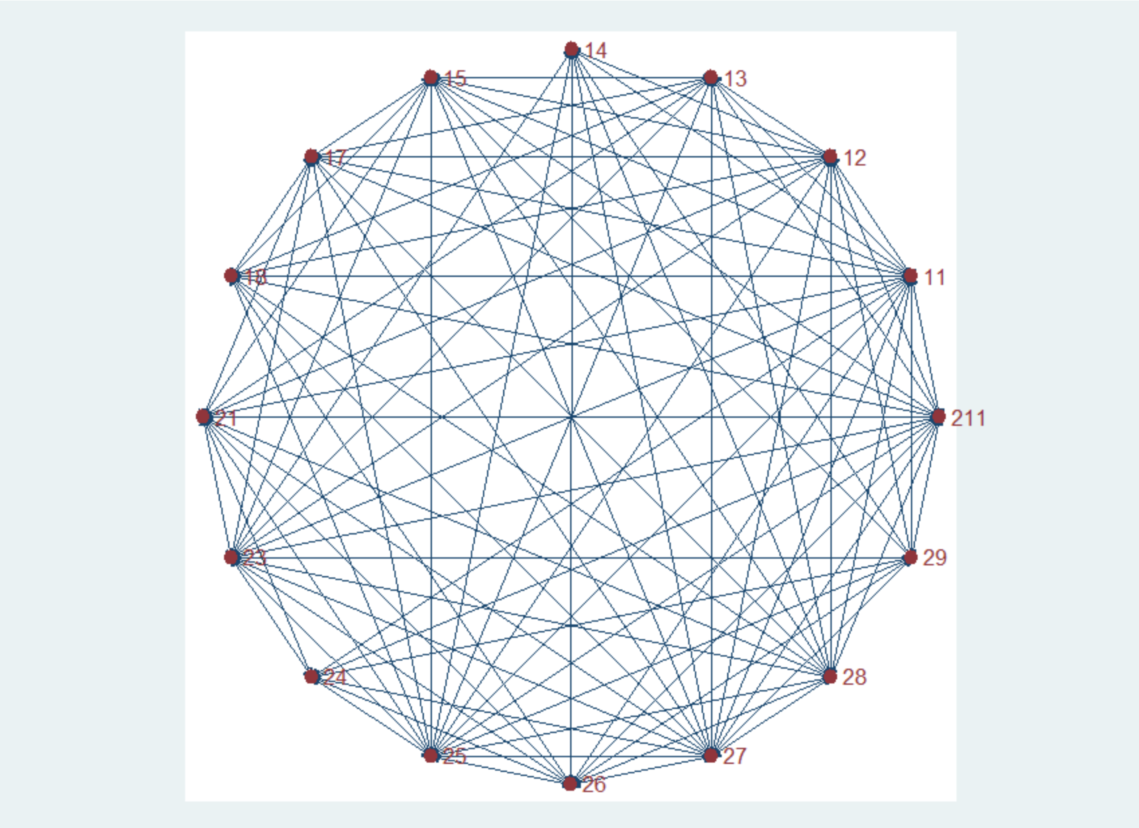


Figure 15: Network ties across all farmers groups (in circle)

A.2.3 *Descriptive Statistics of Farmers Groups' Characteristics*

Summary statistics of farmers groups' characteristics are depicted in Table 44. For each of the variable, average value of group members' characteristics are obtained. An Ordinary Least Square (OLS) regression is employed to see the associations between these basic characteristics and the centrality values. The regression result is presented in Table 43.

Column 1,2,4, and 5 generally show that the size of group is positively associated with the degree- and closeness-centrality measures. Group which has many members tend to have higher propensity to be influential amongst the community, because the size can be associated with the ability to reach more networks. However, when it comes to the determinants of being the information gatekeeper, mobile device and motorbike become an important factor driving betweenness centrality. Group with higher share of mobile or motorbike users are more likely to bridge information transfer across groups due to the aid from these devices.

Table 43: Correlations between group characteristics and centrality measures

Variables	Out-degree Centrality	Out-closeness Centrality	Betweenness Centrality	Out-degree Centrality	Out-closeness Centrality	Betweenness Centrality
	(1)	(2)	(3)	(4)	(5)	(6)
No of mobile phone	-0.00455	0.0279	0.0359**			
	(0.223)	(0.15100)	(0.0118)			
No of motorbike				-0.12300	-0.0622	0.0282*
				(0.20200)	(0.138)	(0.0126)
No of member	0.0163*	0.0117*	-0.000789	0.0165*	0.0118*	-0.000745
	(0.00804)	(0.00544)	(0.000427)	(0.00785)	(0.00538)	(0.000491)
Years of Education	-0.0187	-0.0160	-0.00536*	-0.0196	-0.0119	0.00009
	(0.0533)	(0.0361)	(0.00283)	(0.0405)	(0.0278)	(0.00253)
Cultivated Farmland	0.0184	0.0421	-0.000295	0.0210	0.0265	-0.0204**
	(0.177)	(0.120)	(0.00939)	(0.122)	(0.0838)	(0.00765)
Log of Farm Income	0.1090	0.0643	0.00479	0.1150	0.0715	0.00846
	(0.107)	(0.0722)	(0.00567)	(0.100)	(0.0686)	(0.00626)
Native	-1.3290	-0.9670	-0.0273	-0.8050	-0.6280	-0.06430
	(1.0920)	(0.7380)	(0.0580)	(1.2820)	(0.8780)	(0.0801)
Share of Training Participants	-0.4210	-0.2980	0.0401	-0.4900	-0.3520	0.0333
	(0.4130)	(0.2790)	(0.0219)	(0.3960)	(0.2710)	(0.0247)
Constant	-0.9090	-0.2180	-0.0750	-0.8290	-0.2140	-0.1350
	(1.5230)	(1.0300)	(0.0809)	(1.4720)	(1.0070)	(0.0920)
Observations	16	16	16	16	16	16
R-squared	0.495	0.525	0.738	0.517	0.535	0.653

*Estimation is based on Ordinary Least Square (OLS) methods. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*

Table 44: Summary statistics of farmers group's basic characteristics in 2014

Group Id [a]	N Member	Out-degree Centrality	Out-closeness Centrality	Betweenness Centrality	Average Years of Education	Average Age of House-hold Head	Average Cultivated Farm (in Ha)	Average Log of Farm Income	Average No of Mobile Phone	Average No of Motorbike	Average Share of Native	Average Share of Second Gener-ation Migrant	Average Share of Training Partici-pant
11	20	1.000	1.000	0.032	8.142	43.840	0.99	16.27	1.8	1.45	0	0.65	0.25
12	23	0.867	0.882	0.032	8.180	53.270	1.12	17.116	1.91	1.826	0.13	0.65	0.521
13	10	0.733	0.789	0.032	9.63	45.6	1.000	16.22	2	1.3	0	1	0.3
14	20	0.533	0.682	0.022	9.830	46.500	1.06	16.04	2.25	1.85	0.1	0.8	0.35
15	19	0.800	0.833	0.025	7.200	47.680	0.465	14.95	1.78	1.42	0.105	0.57	0.421
17	18	0.733	0.789	0.015	6.500	41.000	0.55	15.24	1.611	1.55	0.05	0.83	0.277
18	15	0.667	0.750	0.017	9.454	48.640	0.8	15.51	1.73	1.46	0	0.2	0.46
21	29	0.800	0.833	0.012	7.350	48.960	1.12	15.99	1.62	1.58	0.06	0.413	0.48
23	23	0.933	0.938	0.008	7.420	45.700	1.312	15.94	1.3	1.13	0	0.608	0.565
24	17	0.533	0.682	0.014	7.125	41.200	1.62	16.05	1.47	1.941	0.117	0.76	0.35
25	34	1.000	1.000	0.002	9.330	49.840	1.63	16.23	1.58	1.55	0.117	0.44	0.5
26	24	0.733	0.789	0.002	9.000	48.750	0.947	16.15	1.66	1.2	0.041	0.666	0.37
27	15	1.000	1.000	0.009	9.500	46.920	1.57	16.89	2.13	1.8	0.06	0.666	0.066
28	25	0.867	0.882	0.004	7.570	40.040	1.031	16.29	1.36	1.44	0.08	0.64	0.36
29	7	0.667	0.750	0.001	9.000	44.500	1.29	16.15	1.28	0.857	0	1	0.28
211	12	0.933	0.938	0.002	11.050	44.250	2.6	17.36	1.583	1.833	0.083	0.667	0.083

a group Id 16 and 22 had to be dropped because the members were mostly either no longer active, no longer cultivating coffee or cocoa, or unavailable as a group.

A.3 NETWORK PLOTS OF ALL FARMERS GROUPS ACROSS YEARS

Finally, this section concludes with information regarding farmers groups' network structures across the years.

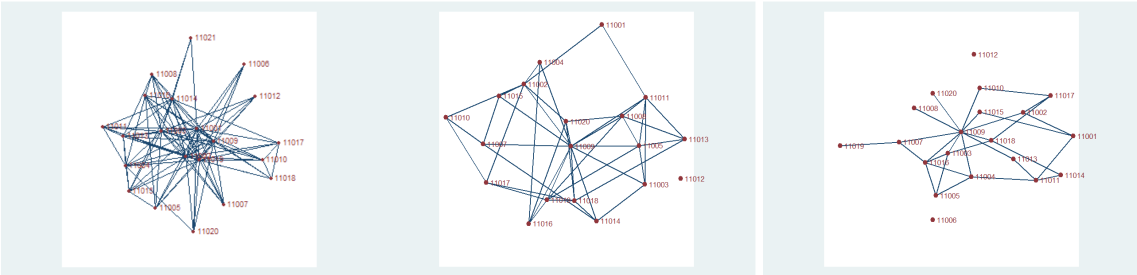


Figure 16: Network structure in 2012, 2013, and 2014 (Group Code 11)

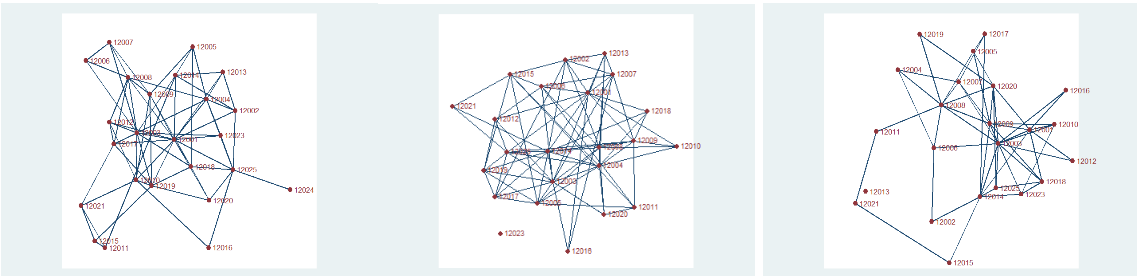


Figure 17: Network structure in 2012, 2013, and 2014 (Group Code 12)

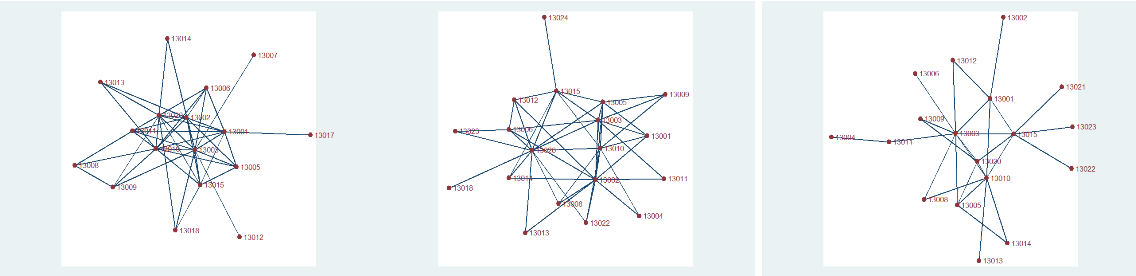


Figure 18: Network structure in 2012, 2013, and 2014 (Group Code 13)

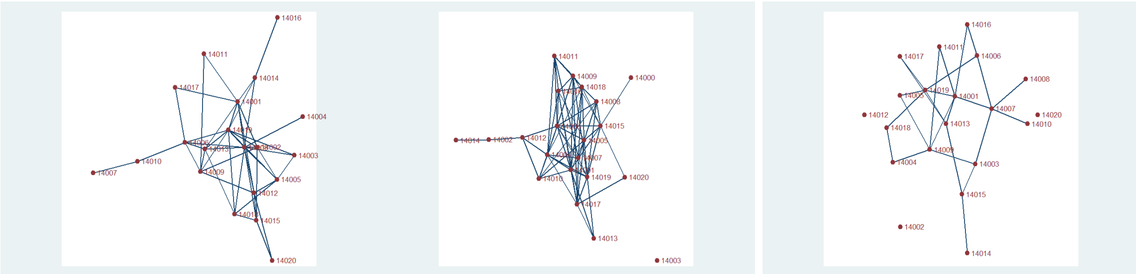


Figure 19: Network structure in 2012, 2013, and 2014 (Group Code 14)

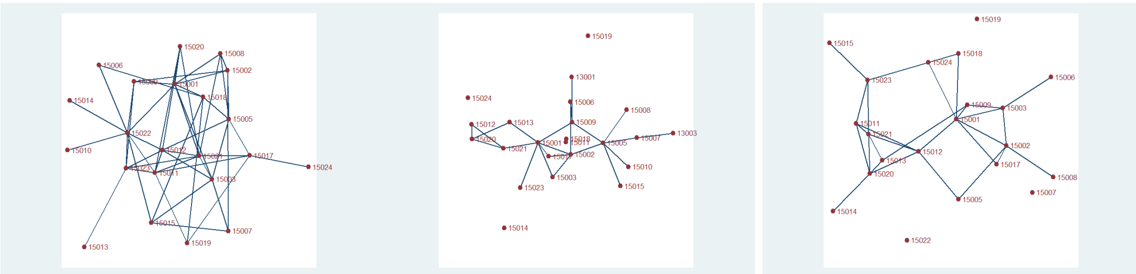


Figure 20: Network structure in 2012, 2013, and 2014 (Group Code 15)

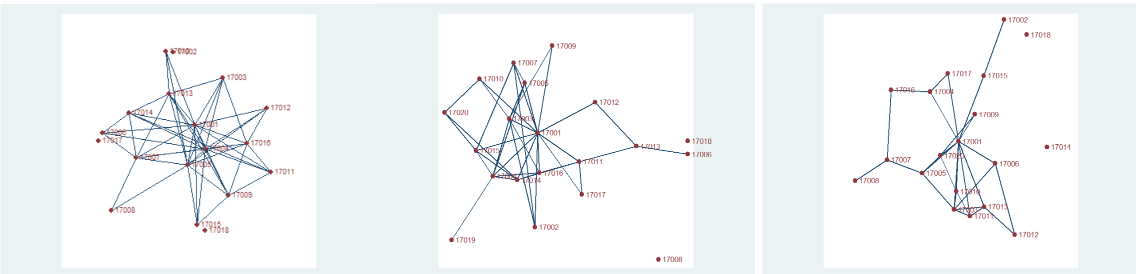


Figure 21: Network structure in 2012, 2013, and 2014 (Group Code 17)

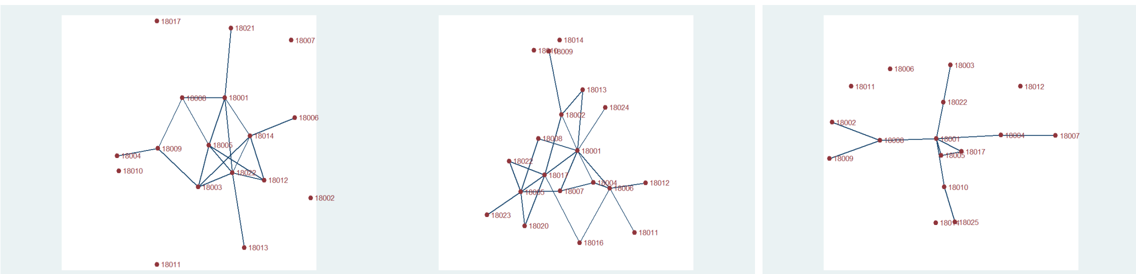


Figure 22: Network structure in 2012, 2013, and 2014 (Group Code 18)

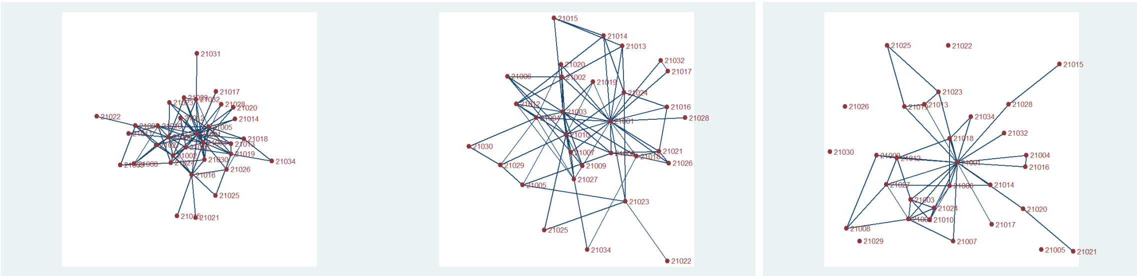


Figure 23: Network structure in 2012, 2013, and 2014 (Group Code 21)

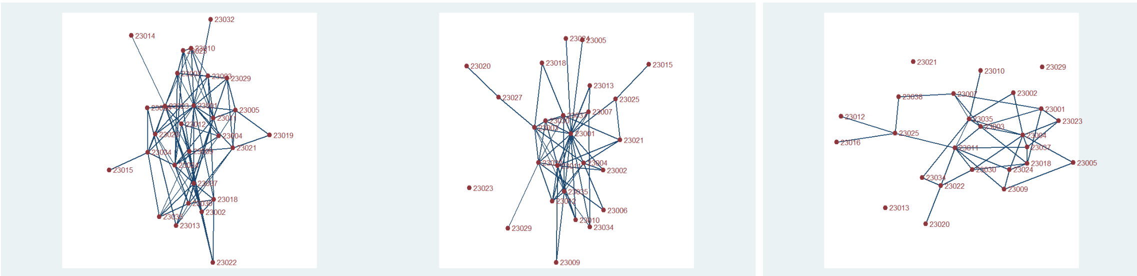


Figure 24: Network structure in 2012, 2013, and 2014 (Group Code 23)

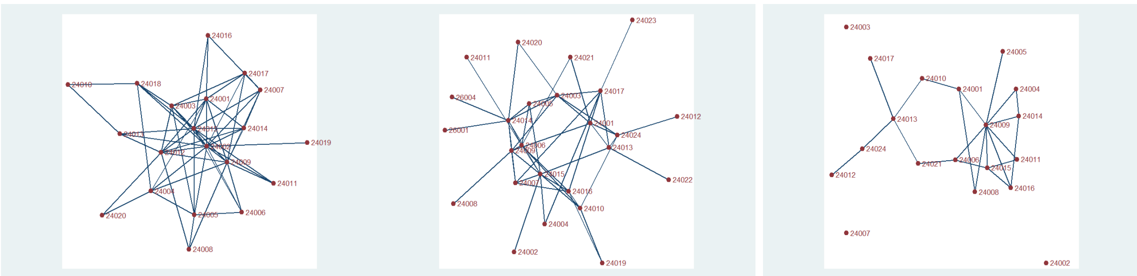


Figure 25: Network structure in 2012, 2013, and 2014 (Group Code 24)

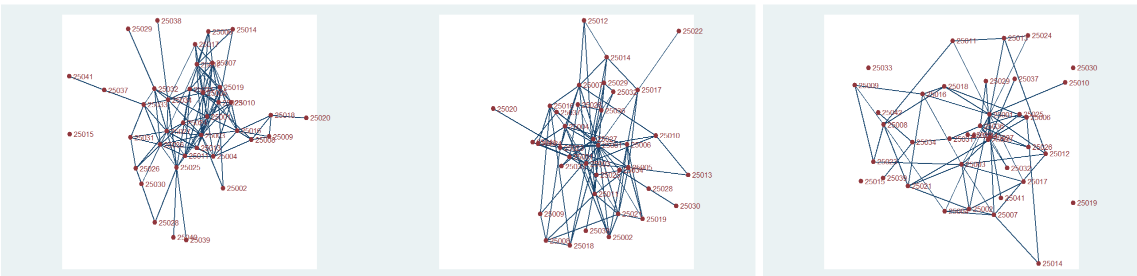


Figure 26: Network structure in 2012, 2013, and 2014 (Group Code 25)

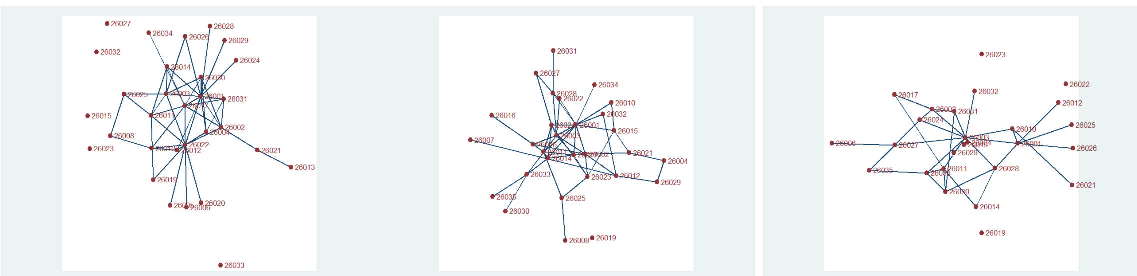


Figure 27: Network structure in 2012, 2013, and 2014 (Group Code 26)

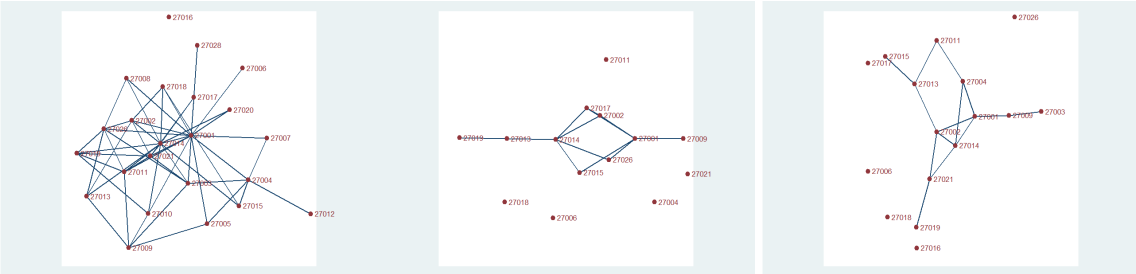


Figure 28: Network structure in 2012, 2013, and 2014 (Group Code 27)

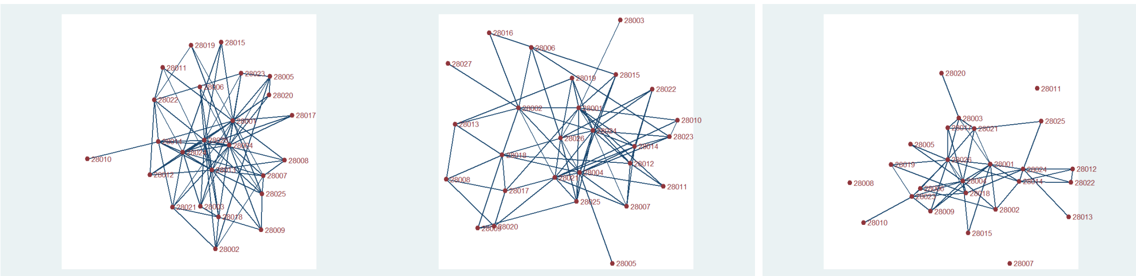


Figure 29: Network structure in 2012, 2013, and 2014 (Group Code 28)

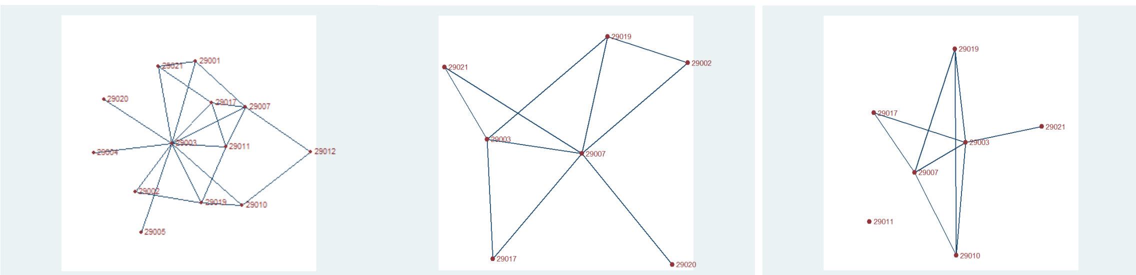


Figure 30: Network structure in 2012, 2013, and 2014 (Group Code 29)

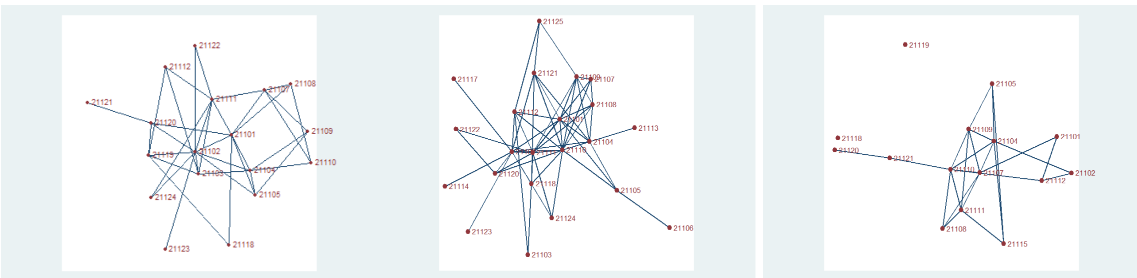


Figure 31: Network structure in 2012, 2013, and 2014 (Group Code 211)

B

ADDITIONAL REGRESSION

B.1 EFFECTS OF PERSONAL NETWORK ON NORMALIZED TEST SCORES

B.1.1 *Overview*

This part serves as additionality to check the robustness of test scores as dependent variables and various network types as independent variables as studied in Chapter 4. I utilize the normalized version of test scores as dependent variables, which are constructed as the value of test scores divided by its standard deviation.

Estimation strategy and variables constructions are identical with those examined in Chapter 4.

B.1.2 *Result*

1. Effect of personal network on learning effectiveness

Table 45 column 1 to 3 present regression results of the influence of personal network on test scores for the case of Coffee farmers. For the case of coffee farmers, I found that for every peers- and expert- (official) advice network a farmer participant has, the test-score post-training will likely to be higher by 0.11 points and 0.06 points out of 10 points respectively. Conversely, having one friend from the same farmers group joining the training, farmers' score will be likely to drop by 0.02 points. Coffee farmers having more friendship ties also have lower score by 0.04 points to begin with, indicating the negative effects of social ties on learning performance. In general, farmers having association with government agents also seem to have lower scores before the training by 0.11 points even though the score increments are significantly higher post-training.

Results for Cocoa farmers are reported in columns 4 to 6. For every peers- and government-advice network farmers have, the coefficient post-training is lower by 0.007 points and 0.16 points respectively. And for every friendship ties, the coefficient will drop by 0.05 points. At the beginning, it may seem that peers-advice network and friendship network have negative association with learning performance. However, in column 4 and 5, the coefficient on friendship network and peer-advice network are positive and significant by 0.013 and 0.05 points respectively, meaning that the scores of farmers who have more of this network were higher from the beginning. Farmers with more peers- and friendship-networks may possibly know the cocoa production better relative to others; hence the increment on the score from the training is smaller than others with fewer networks. On the other hand, farmers with less of these networks learned a lot more from the training because they didn't know it well before. Cocoa is newer, so people don't know it as much as coffee, but those with more networks know it better before the training.

The results presented here are similar with the results obtained in Chapter 4 before the scores are normalized.

Table 45: Effects of network ties on normalized test scores

	Coffee Score (if Coffee Farmers = 1)			Cocoa Score (if Cocoa Farmers = 1)		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Time*Friendship Network	-0.0197***			-0.0538***		
	(0.00219)			(0.000210)		
Time*Advice Network (Peers)		0.112***			-0.00729***	
		(0.00118)			(0.000157)	
Time*Advice Network (Official)			0.0605***			-0.163***
			(0.00142)			(0.000108)
Friendship Network	-0.0391***			0.0132***		
	(0.00337)			(0.00410)		
Advice Network (Peers)		-0.0171			0.0493***	
		(0.0202)			(0.00384)	
Advice Network (Official)			-0.113**			-0.0252
			(0.0486)			(0.0164)
Time (= 1 if Post-lecture)	1.006***	0.523***	0.891***	0.814***	0.645***	0.721***
	(0.0230)	(0.0188)	(0.0159)	(0.00262)	(0.00136)	(0.000432)
Years of Experience of Coffee Farmers	0.000623	0.000415*	0.00226			
	(0.00147)	(0.000244)	(0.00184)			
Years of Experience of Cocoa Farmers				0.00683**	0.00602**	0.0100***
				(0.00323)	(0.00267)	(0.00387)
Years of Education of Household Head	0.0323	0.0330	0.0390	0.0692***	0.0627***	0.0727***
	(0.0301)	(0.0297)	(0.0308)	(0.00525)	(0.00200)	(0.000283)
Cultivated Farmland[1]	-0.000256	0.0196	-0.0402	-0.128	-0.0967	-0.174***
	(0.157)	(0.130)	(0.167)	(0.0829)	(0.0714)	(0.0544)
Possession of Motorbike[2]	0.415***	0.363***	0.450***	-0.0594	0.0263	-0.0672
	(0.0425)	(0.0795)	(0.0247)	(0.359)	(0.423)	(0.384)
Possession of Mobile Phone[2]	-0.283**	-0.233**	-0.18000	-0.0377	0.0871	0.0496
	(0.125)	(0.112)	(0.146)	(0.0510)	(0.0705)	(0.0923)
Living Nearby Extension Agents[3]	0.19700*	0.225**	0.242**	-0.20400	-0.15000	-0.130
	(0.117)	(0.0983)	(0.115)	(0.155)	(0.121)	(0.0986)
Trained Outside Hometown[2]	-0.16300	-0.0931	-0.13600	-0.123**	-0.133**	-0.169***
	(0.278)	(0.247)	(0.279)	(0.0621)	(0.0618)	(0.0405)
No. of Extension Agents Present During Training	0.10800	0.11300	0.0992	0.00443	0.0312**	0.000280
	(0.134)	(0.119)	(0.136)	(0.0106)	(0.0124)	(0.00527)
Constant	0.51600	0.33700	0.32900	3.935***	3.468***	3.964***
	(0.849)	(0.862)	(0.875)	(0.148)	(0.160)	(0.130)
Observations	174	174	174	174	131	129
Number of year	2	2	2	2	2	2
R-squared	0.295	0.323	0.296	0.347	0.220	0.246

[1] *(in Ha)*

[2] *(=1 if Yes)*

[3] *(within 15mins walking distance)*

*Results are based on Random-Effects estimation. Clustered robust standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*

2. Effect of network position on learning effectiveness (only if farmers mention any member in their farmers group as agricultural advice network)

In Table 46, after taking account the normalized test scores, I found that all three network variables, namely degree-, closeness-, and betweenness-centrality are strongly correlated with higher test-scores for both coffee and cocoa farmers respectively. The highest possible closeness- and degree- centrality score attained is 1 if farmers practically mention everyone in their farmers group as source of agricultural advice. After the training, farmers who were close to all people in their group and listed everyone as sources of advice, tend to obtain 1.3 points and 1.6 points higher respectively for coffee farmers, and 0.5 points and 0.04 points for cocoa farmers. The results are similar with the ones presented in Chapter 4.

Table 46: Effects of network position in farmers group on normalized test scores (only for farmers who mentioned any group members as advice network)

	Coffee Score (if Coffee Farmers = 1)			Cocoa Score (if Cocoa Farmers = 1)		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Time*Closeness Centrality	0.50500**			0.296***		
	(0.224)			(0.000235)		
Time*Out-degree Centrality		0.645***			0.0273***	
		(0.154)			(0.000609)	
Time*Betweenness Centrality			1.551***			0.717***
			(0.0758)			(0.00512)
Closeness Centrality	1.581***			0.596***		
	(0.278)			(0.00655)		
Out-Degree Centrality		0.537***			0.558***	
		(0.192)			(0.00466)	
Betweenness Centrality			-0.306***			1.406***
			(0.0435)			(0.358)
Time	0.717***	0.806***	0.896***	0.483***	0.636***	0.600***
	(0.141)	(0.0652)	(0.0263)	(0.00184)	(0.00209)	(0.00179)
Years of Experience of Coffee Farmers	0.000474	0.00100	0.00312**			
	(0.00143)	(0.000995)	(0.00136)			
Years of Experience of Cocoa Farmers				0.00321	0.00376***	0.00572
				(0.00198)	(0.00130)	(0.00436)
Years of Education of Household Head	0.0256	0.0235	0.0278	0.0410***	0.0376***	0.0391***
	(0.0353)	(0.0337)	(0.0314)	(0.00700)	(0.00455)	(0.0106)
Cultivated Farmland[1]	-0.000360	-0.0124	-0.0158	-0.175**	-0.182**	-0.217***
	(0.226)	(0.227)	(0.235)	(0.0724)	(0.0744)	(0.0492)
Possession of Motorbike[2]	0.535***	0.526***	0.501***	-0.18700	-0.19100	-0.24500
	(0.0127)	(0.00533)	(0.000746)	(0.37500)	(0.39100)	(0.38100)
Possession of Mobile Phone[2]	-0.326**	-0.267**	-0.16800	0.173***	0.185***	0.0772***
	(0.134)	(0.112)	(0.10300)	(0.0481)	(0.0478)	(0.0133)
Living Nearby Extension Agents[3]	0.233***	0.239***	0.268**	-0.0835	-0.102	-0.246*
	(0.0777)	(0.0886)	(0.110)	(0.0875)	(0.0920)	(0.144)
Trained Outside Hometown[2]	-0.12700	-0.10300	-0.0711	-0.0922*	-0.0957**	-0.0417
	(0.27000)	(0.27800)	(0.269)	(0.0496)	(0.0450)	(0.0753)
No. of Extension Agents Present During Training	0.0581	0.0664	0.0665	0.00250	0.00643	0.0156
	(0.182)	(0.181)	(0.177)	(0.0102)	(0.0106)	(0.0152)
Constant	-0.18600	0.41100	0.42200	3.958***	4.122***	4.282***
	(1.26800)	(1.20900)	(1.15100)	(0.180)	(0.183)	(0.195)
Observations	150	150	150	111	111	111
Number of year	2	2	2	2	2	2
R-squared	0.332	0.325	0.313	0.240	0.245	0.267

[1] *(in Ha)*

[2] *(=1 if Yes)*

[3] *(within 15mins walking distance)*

*Results are based on Random-Effects estimation. Clustered robust standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.*

C

REGRESSION FIT PLOT

C.1 OVERWIEW

This part presents the selected regression fit plot of all the regression result in Chapter 4, 5, and 6. I use the main independent variables i.e. training variable or network centrality and the independent variable to construct the regression fit plot.

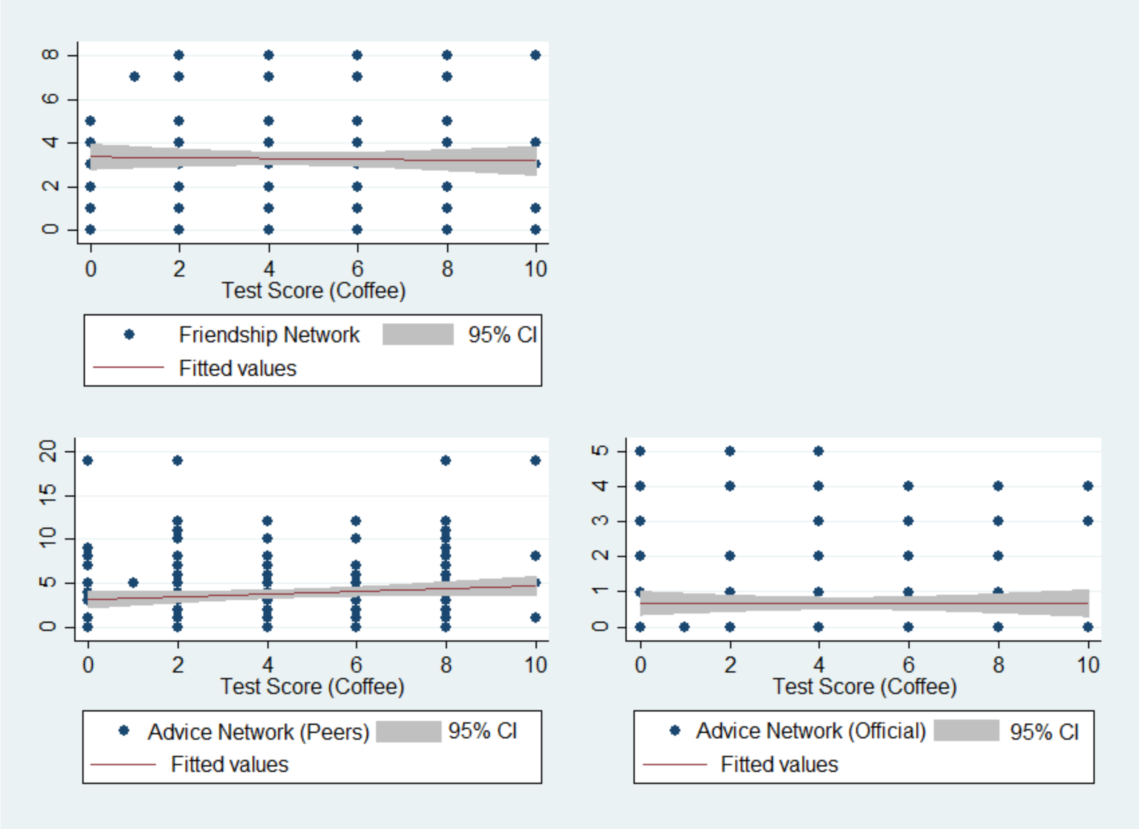


Figure 32: Regression fit plot of personal network on test scores (Coffee)

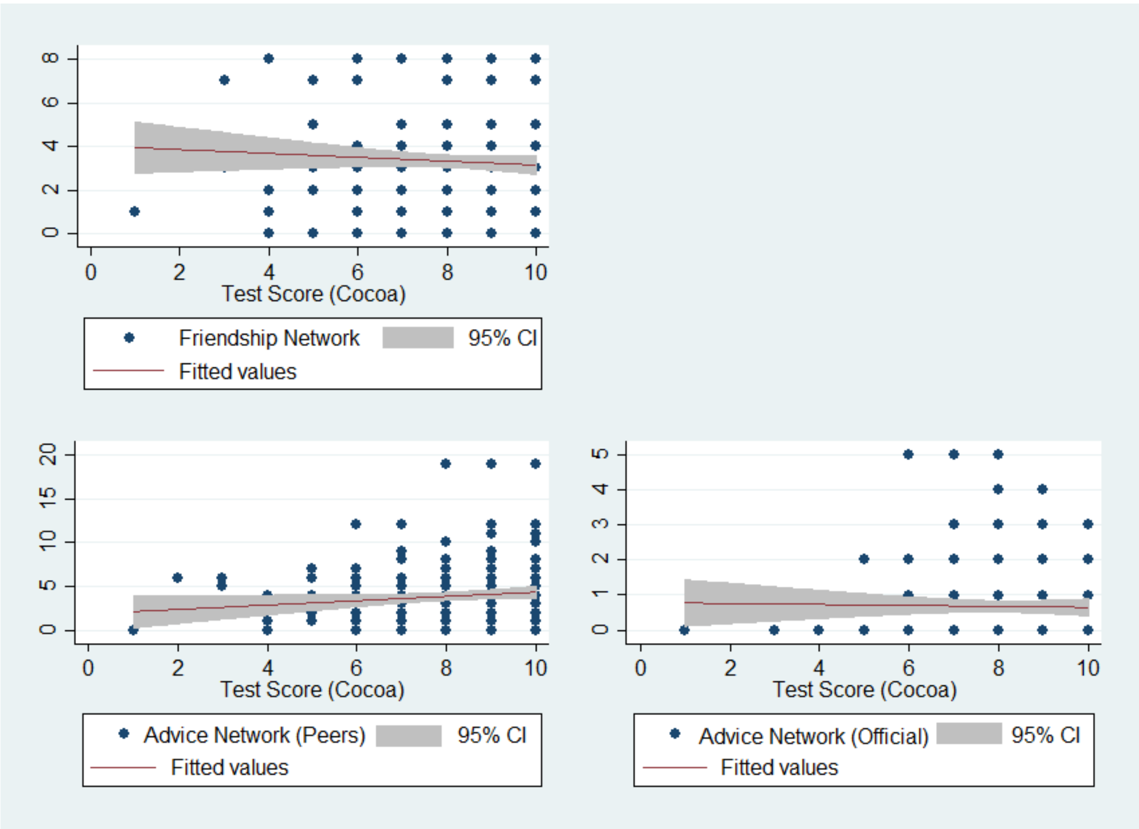


Figure 33: Regression fit plot of personal network on test scores (Cocoa)

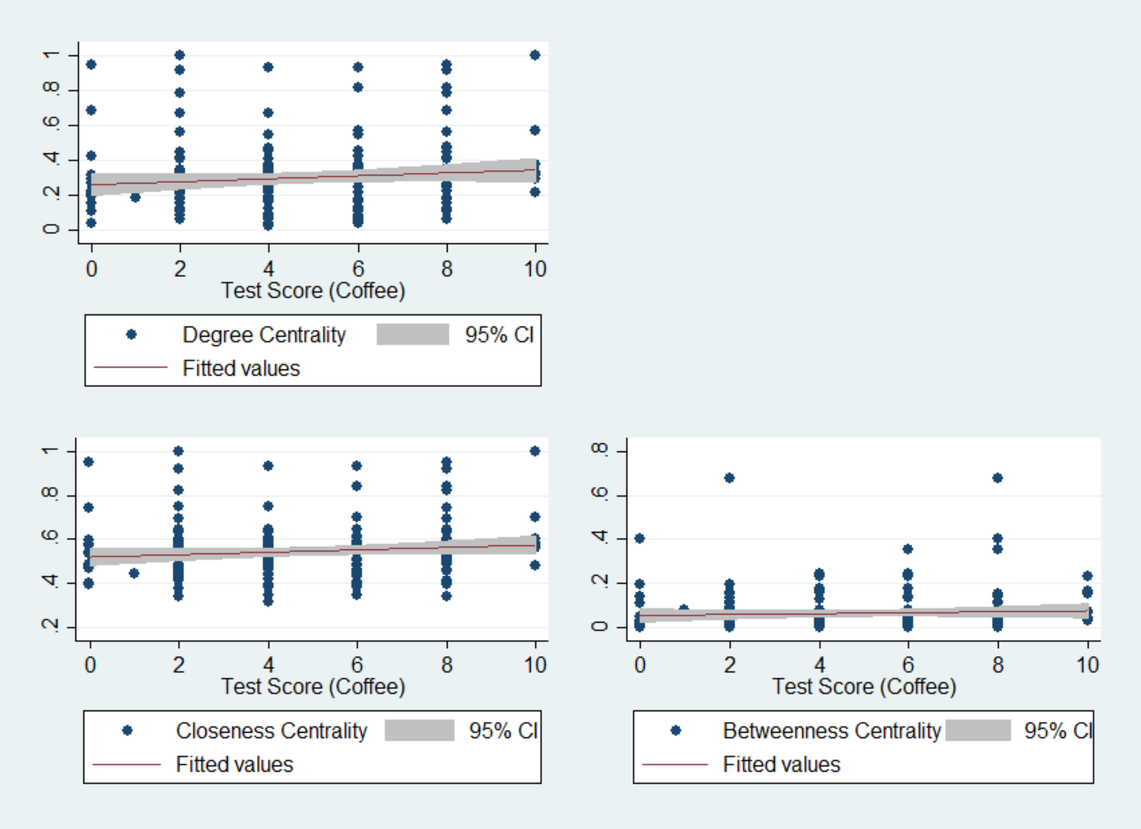


Figure 34: Regression fit plot of network structural position on test scores (Coffee)

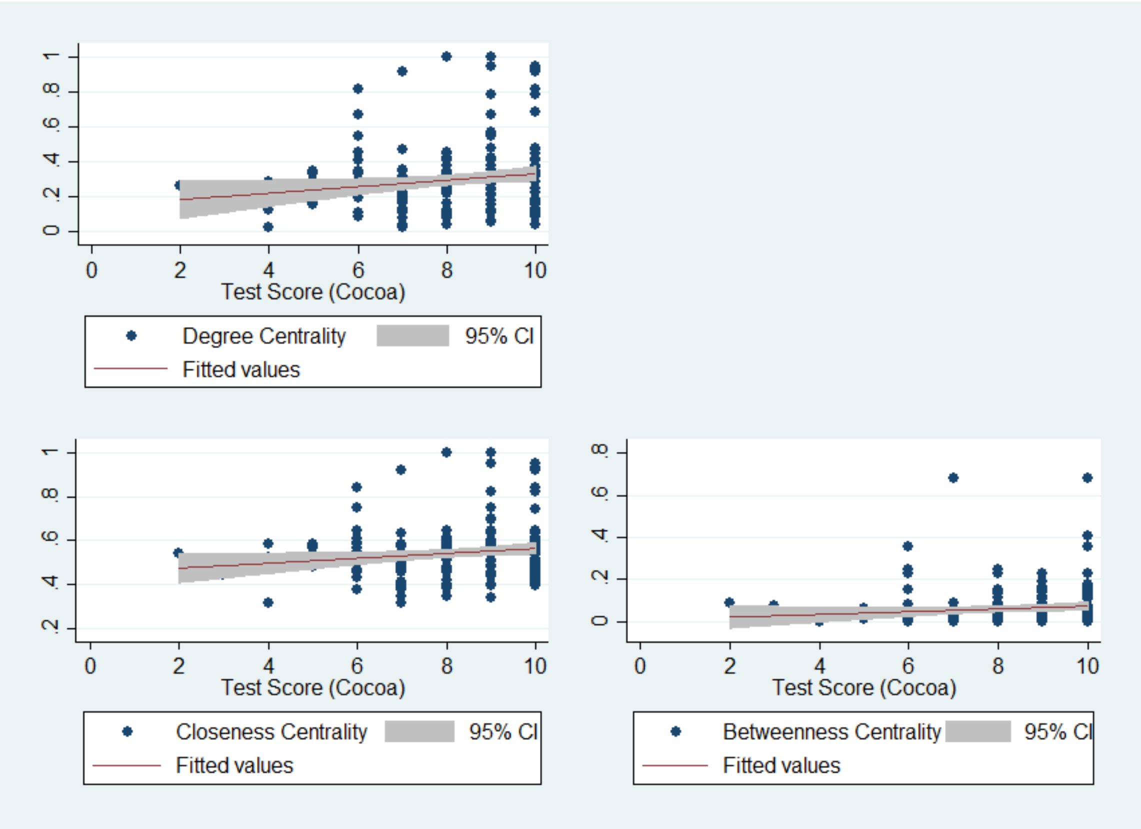


Figure 35: Regression fit plot of network structural position on test scores (Cocoa)

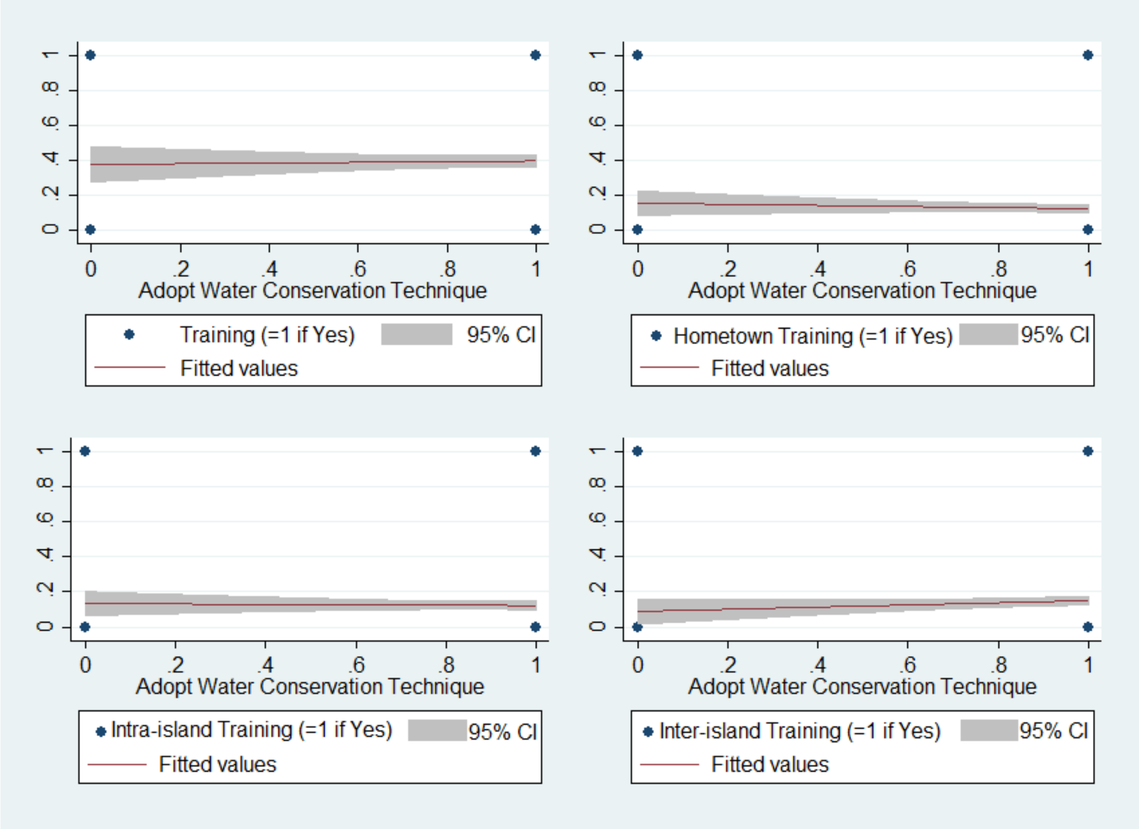


Figure 36: Regression fit plot of training variables on adopting water conservation technique

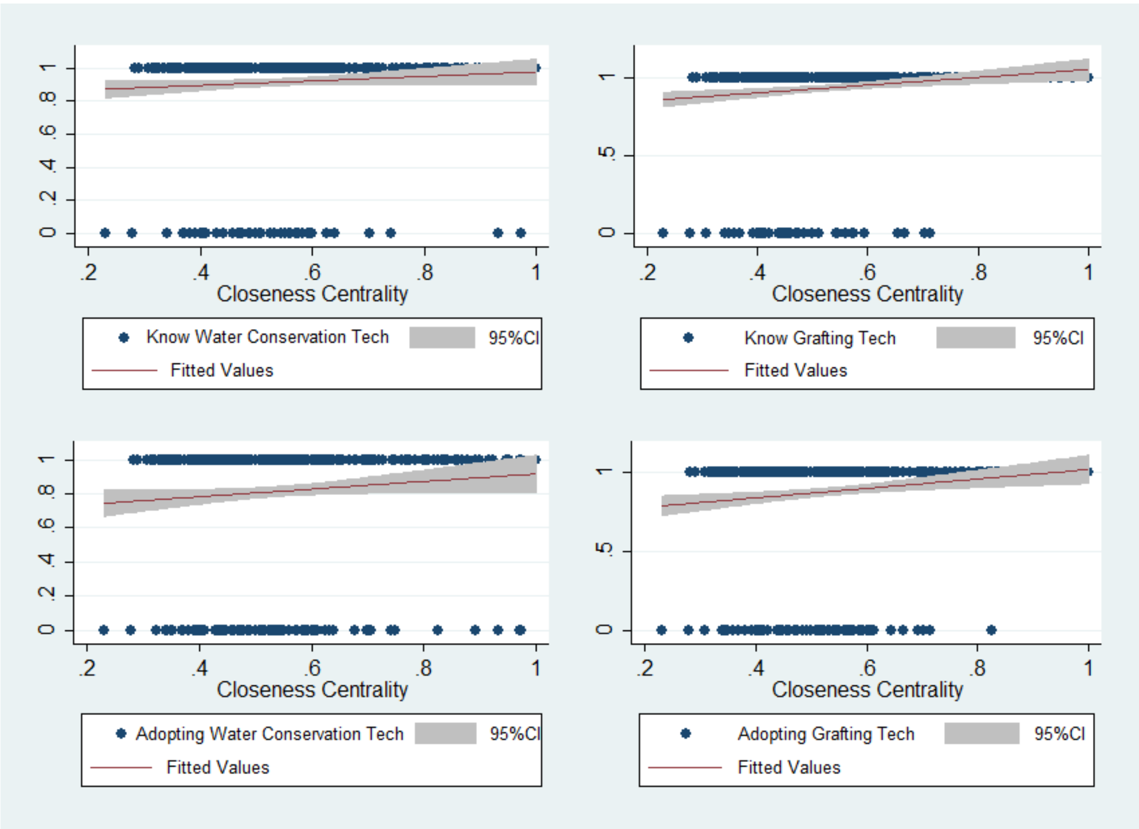


Figure 37: Regression fit plot of closeness centrality on technology diffusion and adoption

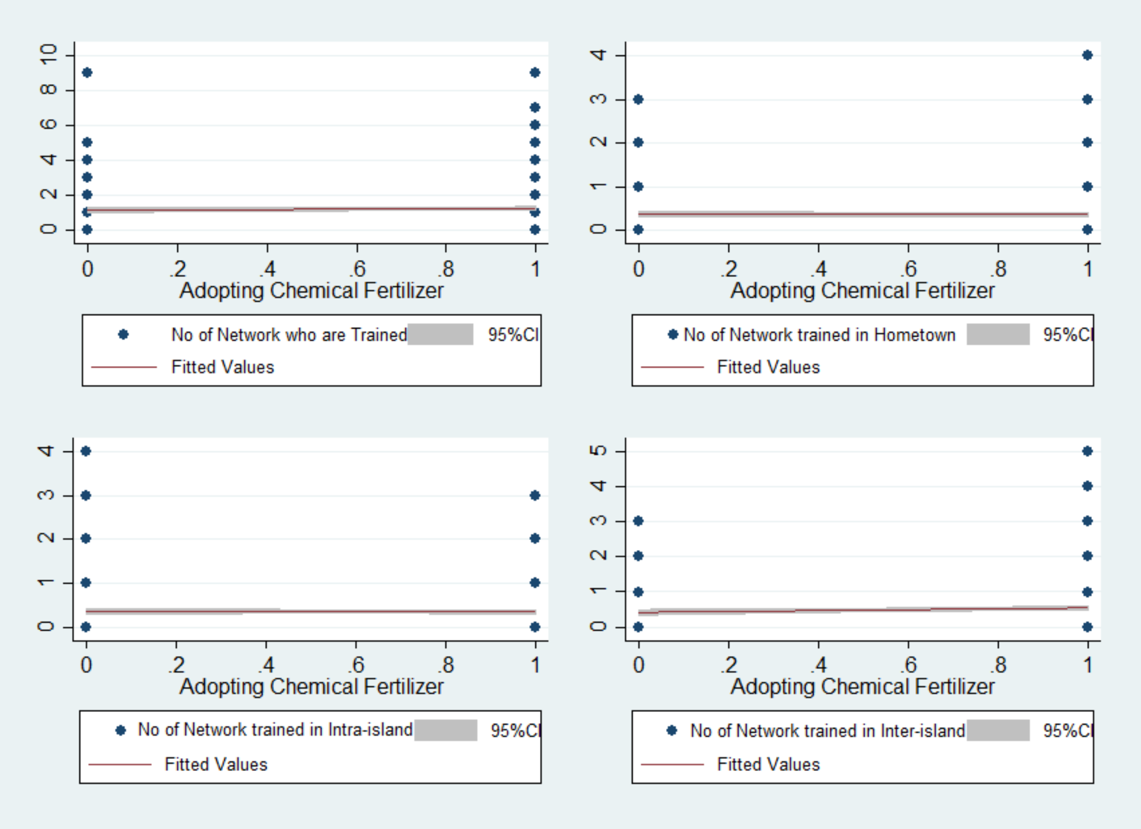


Figure 38: Regression fit plot of network with training participant on chemical fertilizer usage

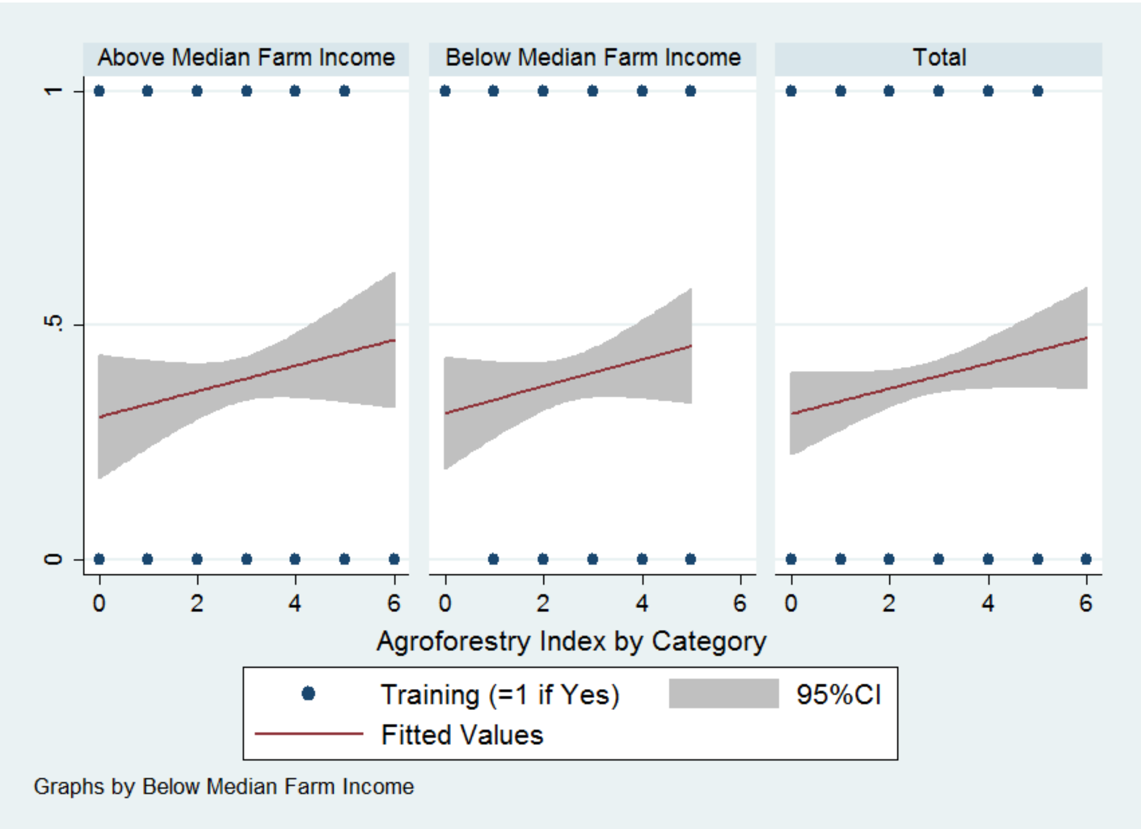


Figure 39: Regression fit plot of training variable on agroforestry index by category

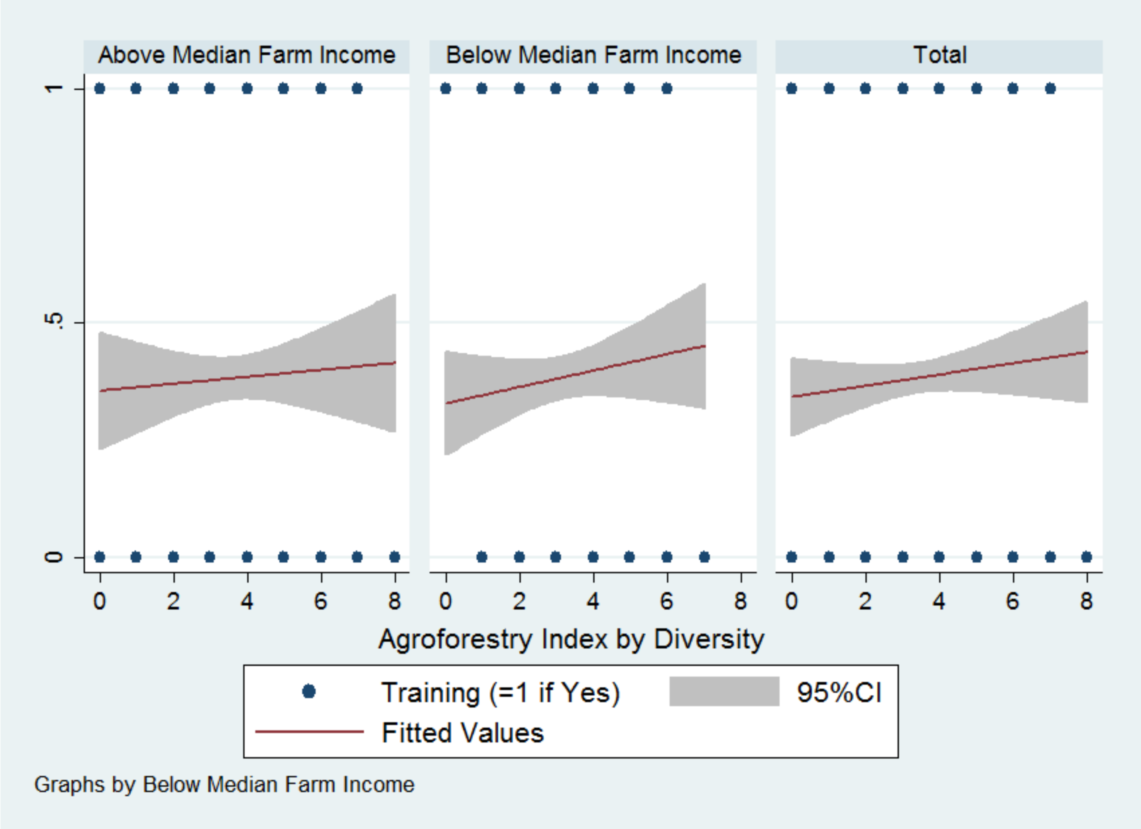


Figure 40: Regression fit plot of training variable on agroforestry index by diversity

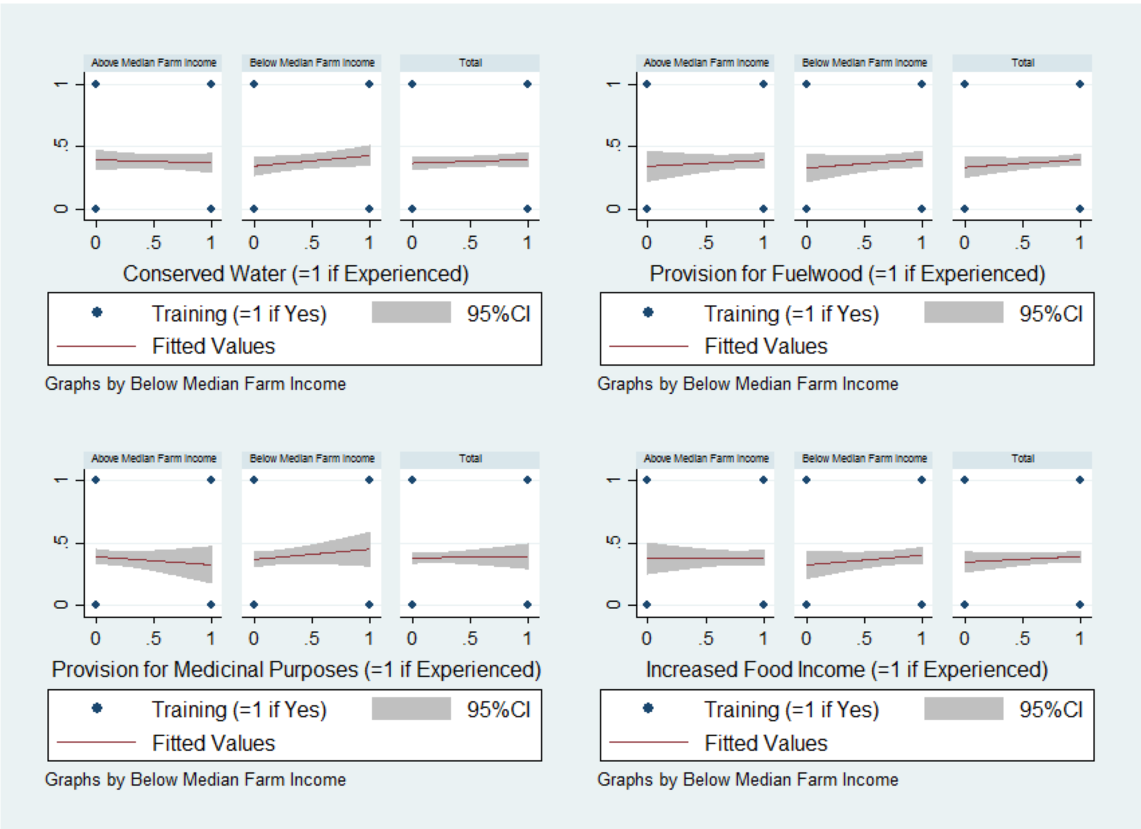


Figure 41: Regression fit plot of training variable on perceived benefits of agroforestry

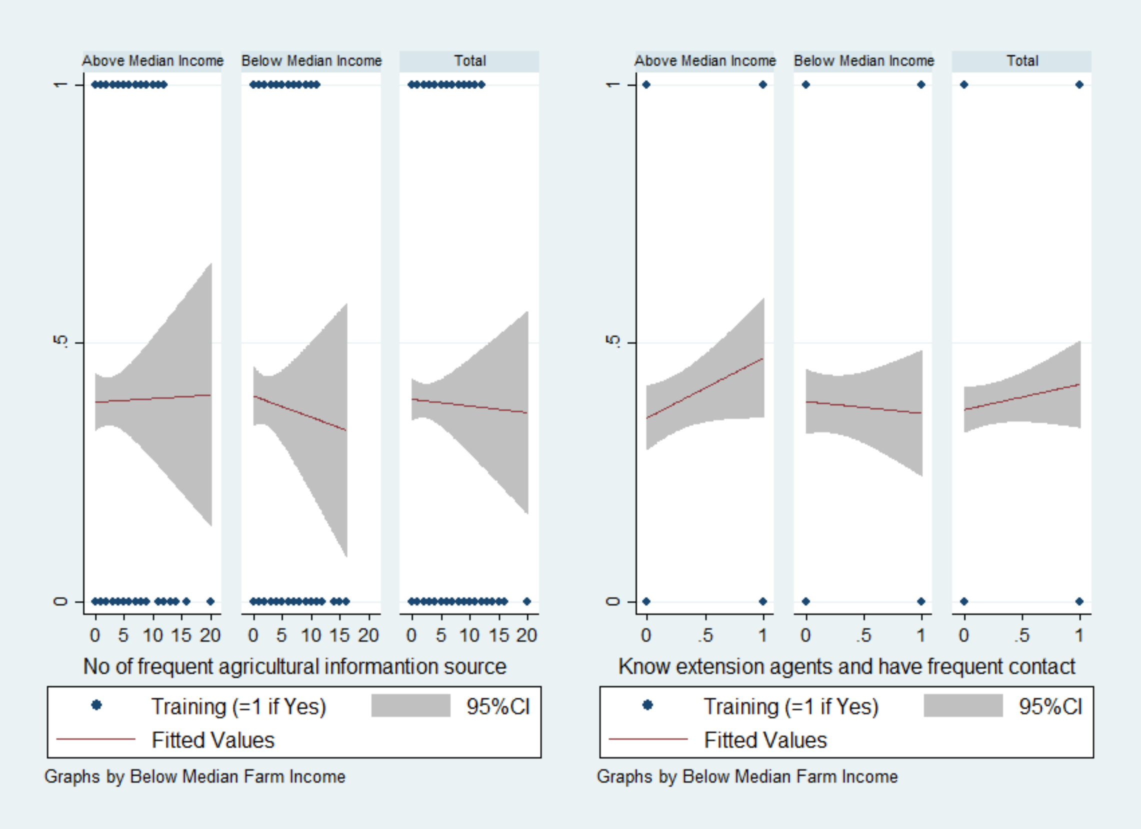


Figure 42: Regression fit plot of training variable on size and depth of social network

Figure 43: Regression fit plot of degree centrality on agroforestry index

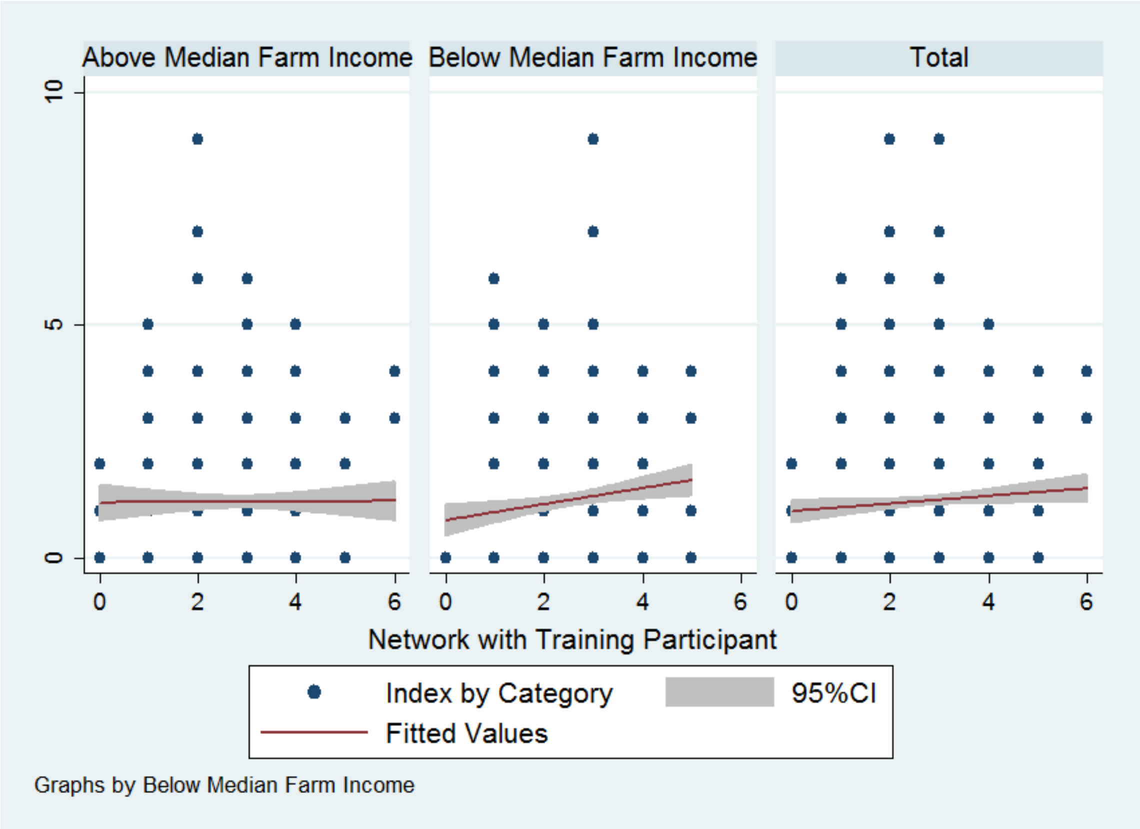


Figure 44: Regression fit plot of network with training participants on agroforestry index by category

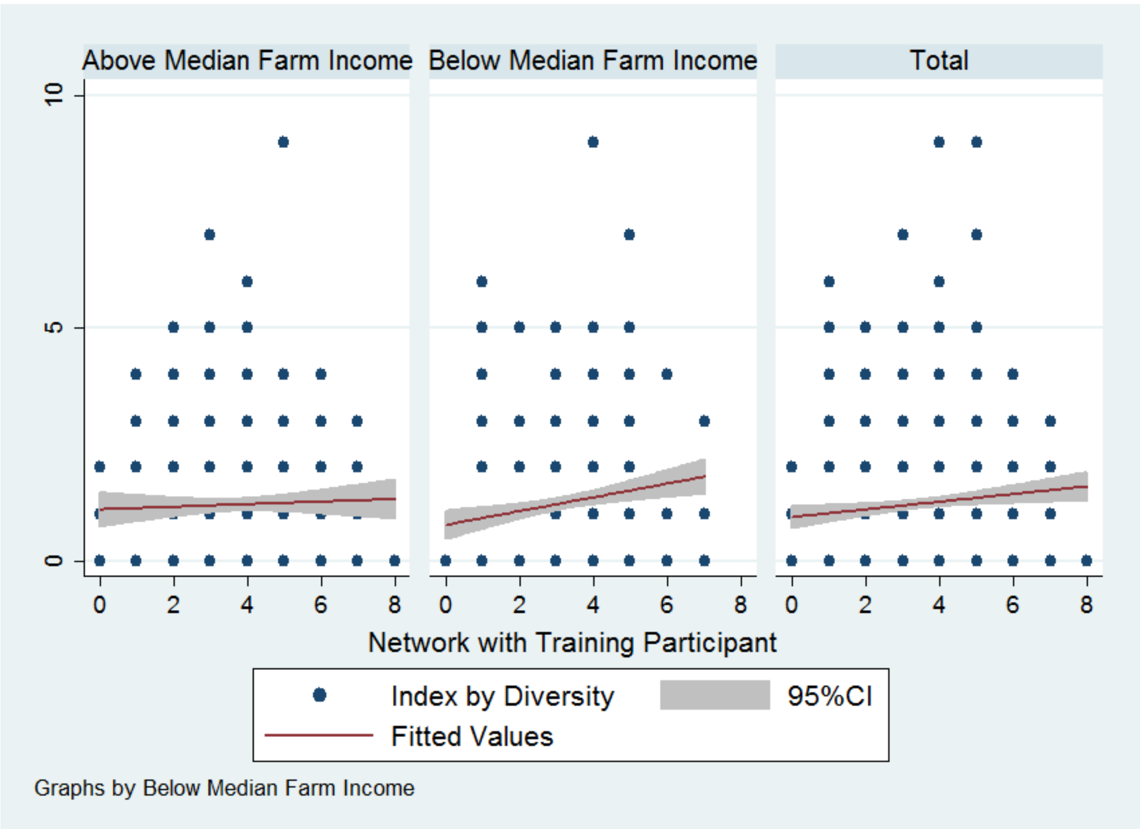


Figure 45: Regression fit plot of network with training participants on agroforestry index by diversity

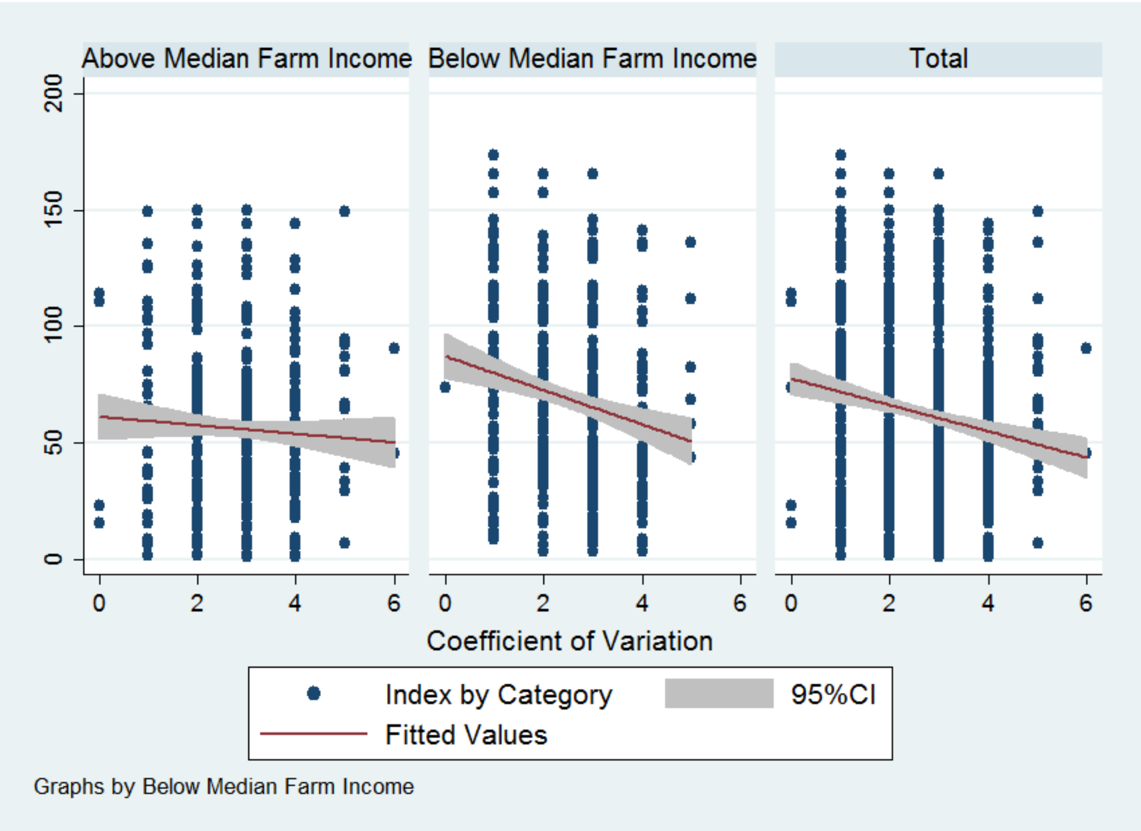


Figure 46: Regression fit plot of agroforestry index on coefficient of variation

Part II

APPENDIX

Household-Level Survey on "Quantitative Analysis of Effects of Social Networks on the Diffusion of Agricultural Technology in Rural Villages of Indonesia

[Note to Enumerator] Please meet the household head. If the household head is not available, ask the most influential person in the household besides the head (such as the spouse or a child of the head). If either the household head or the most influential person is not available, do not continue the survey. For those questions which are not applicable to the household, please write 'na' (not applicable means the question is irrelevant to ask the household).

Please read the "Explanation to Participants" to the respondent. If s/he agrees to respond, please ask her/him to sign here.

I agree to respond to this survey. (signature) ______________________________ .

	Day	Month	Year	Name
Interviewer				
Respondent				
Data Checked				
Data Entered				

	Sub-Regency	Village (*Pekon*)
Name		
Code		

HH ID (XYYZZZ**,** X=Sub-regency/District code (1-3), YY= Farmers group code (1-9), ZZZ=household code (1-40)) **HH ID** ___________|

HH0a-c GPS coordinates

HH0a	**HH0b**	**HH0c**
North (xxx°xx.xxx) [NOT xxx.xxx]	East (xxx°xx.xxx) [NOT xxx.xxx]	Altitude
° .	° .	m

HH0d Is this household available for an interview?
1. Yes, 2. No (refused), 3. No (no contact), 4. No (no head or influential person) 5. No (Other reason) **HH0d** ____________

HH0e If you are not the household head, what is your relationship to the household head?
1. Wife, 2. Children, 3. Parents, 4. Parents in law 5. Siblings 6. Others **HH0e**____________

Section 1b. Demography

[Enumerator] I would like to ask you some questions about your household members. We consider someone a member of the household if they usually live and eat in the household for at least one month in the last 12 months. Thus, any son or daughter who is living outside the house (for example, in a different village or town) is not a member of the household.

ID	Name [Note to Enumerator] Write the name of the respondent in the first row.	Sex 1=Male 2=Female	Relation to household head 0=Head 1=Spouse 2=Parent (in law) 3=Child/ grand-child (in law) 4=Other relative 5=Non-relative	Age	Place of birth 1=Lampung 2=Java island 3=South Sumatra 4=Bali 5=Borneo 6=Sulawesi 7=Others	Highest grade completed (or currently enrolled in) 0= Don't go to school 1= Didn't complete elementary school 2= Elementary school 3= Junior High School 4= Senior High School 5= Diploma 1 6= Diploma 2 7= Diploma 3 8= Undergradute 9= Post-graduate	How many units of mobile phone does he/she currently have? (if a phone is shared in the household, be careful not to double count)	Does he/she use a mobile phone at least once a week? 1=Yes 2=No 3=Don't know	Is this person ...? 1=Working full-time (including house work) 2=Working part-time (including house work) 3=A student 4= Housewife 5=Other	Type of the non-farm (non-agriculture) activity (If the person is engaged in more than one activities, please choose only one from which the person gains most.) 1= None 2= Self-employed 3= Employed in manufacturing (e.g., tailor, metal work, furniture, pottery) 4= Employed in non-manufacturing (e.g., small shop, restaurant, driver) 5= Civil Service (government)	Total net income (in cash and in kind) received from all non-farm business in the last 12 months (Rupiah)
ID	**NAME**	**D1**	**D2**	**D3**	**D4**	**D5**	**Dn1**	**Dn2**	**Dn3**	**Dn4**	**Dn5**
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											

H1g. How many times a year do you go to Bandar Lampung? **H1g** ___________

Section 1c. Migration

[Enumerator] Now, I will ask about migrants of your household since September 2012 the last time we visited you. There are 2 types of migrants: (1) current household members who used to live outside Tanggamus for more than 6 months in total; (2) former household members who are or were living outside Tanggamus for more than 6 months in total (excluding those who passed away).
[Note to Enumerator] In the case of (1) above, Dm1-Dm4 should be ignored. Use the same ID number as used in the previous page. In the case of (2), ID should be ignored.

ID	Name	Sex 1=Male 2=Female	Relation to household head 0=Head 1=Spouse 2=Parent (in law) 3=Child/ grand-child (in law) 4=Other relative 5=Non-relative 6= Parents	Age	Highest grade completed (or currently enrolled in) 0= Don't go to school 1= Didn't complete elementary school 2= Elementary school 3= Junior High School 4= Senior High School 5= Diploma 1 6= Diploma 2 7= Diploma 3 8= Undergradute 9= Post-graduate	What is the main occupation? [Note to Enumerator] Let them answer freely and choose the most appropriate one. For current migrants, Dm5 =Dm7. 1=Farming/other job in agriculture 2=Manufacturing 3=Construction 4=Domestic helper 5=Driver 6=Salary earner in public sector (e.g. teacher, policeman) 7= Salary earner in non-profit sector 8=Self employed 9=Housewife 10=Student 11=Other (specify) Now	Before migration	During migration	In which year did this person migrate for the first time?	Migration destination (If more than one destinations, record the main destination) 1=Jakarta 2=Other city/town in Lampung 3= Other city/town in Java Island 4= Other city/town in Indonesia 4=Middle East 5=Asia 6=Developed countries (e.g., US, Australia, Europe) 8=Other countries	Total duration of migration (months)	Annual remittance from this person to the household in the most recent 12 months [Rupiah]	In which year did this person come back to Tanggamus? [Write "999" if still out of the village]	Reason of return to Tanggamus: 1=Disaster 2=Disease 3=Riot 4=Contract ends 5=Cannot find jobs 6=Other
ID	**NAME**	**Dm1**	**Dm2**	**Dm3**	**Dm4**	**Dm5**	**Dm6**	**Dm7**	**Dm8**	**Dm9**	**Dm10**	**Dm11**	**Dm12**	**Dm13**
	Example (1)													
	Example (2)													

Section 2. Parcels Operated

HH2a How many hectares of land did your household own in 2013? (land for which you have or not have a land certificate, including rented out land)
[Note to Enumerator] Use the followings to sum up different parcels. _____ + _____ + _____ + _____ + = **HH2a**__________ ha

HH2b How many hectares of land does your household cultivate (both owned and rented) in 2013?
_____ + _____ + _____ + _____ + = **HH2b**__________ ha

Section 3. Agricultural Inputs

[Enumerator] I would like to ask questions about inputs in total for all crops you produced in 2013.

Chemical fertilizer use (largest amount)		Chemical fertilizer use (2nd largest amount)		Organic fertilizer use (largest amount)		Organic fertilizer use (2nd largest amount)	
Type 1= ZA 2= UREA 3= TSP 4= NPK 5= mixed 6= Other	Amount (kg)	Type 1= ZA 2= UREA 3= TSP 4= NPK 5= mixed 6= Other	Amount (kg)	Type 1= Dry animal manure 2= Fresh animal manure 3= Compost 8= Other	Amount (kg)	Type 1= Dry animal manure 2= Fresh animal manure 3= Compost 8= Other	Amount (kg)
CT7	**CT8**	**CT9**	**CT10**	**CT11**	**CT12**	**CT13**	**CT14**

HH3a Could you borrow sufficiently for your input use for the last 12 months? 1 = Yes, 2 = No, 3 = I didn't want to borrow.
(If 1or 3 Skip to Sec. HH3e.) **HH3a** ___________

HH3b How much more would you have wanted to borrow (% of total input purchases in the last 12 months)? **HH3b** ___________

HH3e Did the household hire labors for crop production in 2013?

Personal labors (HH3ei) _____ + Family labors (HH3eii)_____ + Hired labors (HH3eiii)_____ **HH3e** ___________

HH3f What sort of farm work did the household engage labor for? (Tick whichever is applicable)
Cultivation (HH3fi): labor(HH3fia)_____(person) x Workdays(HH3fib) _____ (days) x Wedges per day(HH3fic) ________ (Rp) (HH3fi_total) = ______________
Planting(HH3fii): labor(HH3fiia)_____(person) x Workdays(HH3fiib) _____ (days) x Wedges per day(HH3fiic) ________ (Rp) =(HH3fii_total) ________________
Weeding (HH3fiii) : labor(HH3fiiia)_____(person) x Workdays(HH3fiib) _____ (days) x Wedges per day(HH3fiiic) ________ (Rp) =(HH3fiii_total) _____________
Harvesting/post-harvest (HH3fiv) : labor(HH3fiva)___(person) x Workdays(HH3fivb) __ (days) x Wedges per day(HH3fivd) ___ (Rp) =(HH3fivd_total) _________

Section 4. Agricultural Production

[Enumerator] I would like to ask questions about production of the crops you produced in 2013. If you produced more than 5 types of crop, choose the largest 5 and tell me the estimated income from the rest of the crops. (check whether total production or production per hectare is better)

	Crop	Crop Code	Hectares of Land (Ha)	Quantity of Crop	Number of Production per hectare (kg)	Average price per kg (If not sold, market expectation in the market)	Yield sold until September 2013	Actual selling (Rp) (F5 x F6)
	CNama	**CID**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
1	Robusta coffee							
2	Cocoa							
3								
4								
5								

F11 How much in Rupiah did you receive from production of other crops not shown in the list above in 2013 (including estimated value of home use)?
_____ + _____ + _____ + _____ + = **F11 _____________ Rupiah**

F12 How much in Rupiah did you receive from other agricultural activities including production of dairy products, honey, and cattle in 2013 (including wage labor in agriculture)?
_____ + _____ + _____ + _____ + = **F12 _____________ Rupiah**

Plant/Crop Code

Cereal	Legume	Roots	Indus. Crops	Spices	Vegetables	Fruits	Fruits	Hard Wood	Pakan Ternak	Others
1= Padi 2= Jagung 3=Gandum (Terigu) 4= Jewawut 5= Jelai 6= Gandum hitam	7= Kedelai 8= Kacang polong 9= Kacang hijau 10= Petai 11= Jengkol 12= Kacang Tanah 13=Kacang almond	14= Singkong 15= Kentang 16= Ubijalar 17= Talas 18= Lobak 19= Ketela	20= Kopi Robusta 21=Kopi Arabica 22= Kapas 23= Tebu 24= Teh 25= Tembakau 26= Kakao 27= Kelapa Sawit 28 = Kelapa Dalam 29= Pinang 30= Karet	31= Kayu Manis 32= Jinten 33= Jahe 34= Lada Putih 35= Lada Hitam 36= Cabe Jawa 37= Cabai Rawit 38= Cabe Besar 39= Biji Pala 40= Vanilla 41= Kunyit 42= Cengkeh 43= Bawang Merah 44= Bawang Putih 45= Bawang Bombay	46= Kubis 47= Paprika 48= Ketimun 49= Terong 50= Selada 51= Labu 52= Labu siam 53= Bayam 54= Squash 55= Tomat 56= Kacang Hijau 57= Kol kembang 58= Wortel 59= Jamur	60= Durian 61= Manggis 62= Salak 63= Pisang 64= Nanas 65= Semangka 66= Mangga 67= Jeruk 68= Rambutan 69= Melon 70= Apel 71= Asam jawa 72= Alpukat 73= Sirsak	74= Pepaya 75= Pir 76= Persik 77= Plum 78= Melon manis 79= Jeruk keprok 80= Jeruk citrus 81= Anggur 82= Stoberi 83= Sukun 84= Duku	85= Jati 86= Mahoni 87= Damar 88= Rotan 89= Bambu 90= Beringin 91= Jambon 92= Albasia 93= Kayu Lain-lain	94= Rumput Gajah 95= Daun pakan ternak 96= Pasture (selain rumput gajah)	97= Madu 98= *Dadap* 99= *Lamtoro*

Section 5a. Agroforestry (Crop Diversity)

[Enumerator] I would like to ask questions about each of your plot. How many hectares of land do you own and tell us about the plants and how long have you been planting?

Plot 1: Owned______ (hectare) / Cultivate______ (hectare)

G13	Distance from home (Minutes)	

Cereal	Duration (year)	Legume	Duration (year)	Indus. Crops	Duration (year)	Spices	Duration (year)	Vege-tables	Duration (year)	Fruits	Duration (year)	Hard wood	Duration (year)	Other	Duration (year)
A1	AY1	A2	AY2	A3	AY3	A4	AY4	A5	AY5	A6	AY6	A7	AY7	A8	AY8

Plot 2: Owned______ (hectare) / Cultivate______ (hectare)

G132	Distance from home (Minutes)	

Cereal	Duration (year)	Legume	Duration (year)	Indus. Crops	Duration (year)	Spices	Duration (year)	Vege-tables	Duration (year)	Fruits	Duration (year)	Hard wood	Duration (year)	Other	Duration (year)
A1	AY1	A2	AY2	A3	AY3	A4	AY4	A5	AY5	A6	AY6	A7	AY7	A8	AY8

Plot 3: Owned______ (hectare) / Cultivate______ (hectare)

G133	Distance from home (Minutes)	

Cereal	Duration (year)	Legume	Duration (year)	Indus. Crops	Duration (year)	Spices	Duration (year)	Vege-tables	Duration (year)	Fruits	Duration (year)	Hard wood	Duration (year)	Other	Duration (year)
A1	AY1	A2	AY2	A3	AY3	A4	AY4	A5	AY5	A6	AY6	A7	AY7	A8	AY8

Section 5b. Agroforestry (Perception of the Benefits)

[Enumerator] I would like to ask questions about the benefits you feel you are getting after implementing *plant diversification*.
Note: Enumerator asks about the benefit of each agroforestry techniques and circle the designated row.

Benefit of Agroforestry Techniques		**Yes**	**No**	**Neutral**	**Don't know**
Increased soil fertility	E1	1	2	3	9
Increased farm income	E2	1	2	3	9
Conserved soil and water	E3	1	2	3	9
Reduced chances of complete crop failure	E4	1	2	3	9
Maintained/improved surrounding condition	E5	1	2	3	9
Provision of shade by trees (for coffee and cocoa)	E6	1	2	3	9
Variety of food income	E7	1	2	3	9
Extraction of trees for medicinal purpose	E8	1	2	3	9
Extraction of trees for fuelwood	E9	1	2	3	9
Extraction of trees for fodder	E10	1	2	3	9

Section 5c. Agriculture Technologies

[Enumerator] Now, I will ask some questions about agricultural technologies. Please answer the following questions for each type of technology.

[Note to Enumerator] Please ask all questions (including those in the next page) for WH first, then questions for SG, and finally questions for BG.

		Wind Holes	Side-cleft Grafting	Bud Grafting
	Technology ID	**WH**	**SG**	**BG**
T0	Have you heard of this technology? (WH, SG, BG)? 1=Yes, 2=No (if no, skip to the next section.)			
T0a	In which year did you first hear about this technology/know about this technology? 10= this year (2013) between January – March, 11 = this year (2013) between April – August, 1 = last year (2012), 2 = 2 years ago (2011), 3 = 3 years ago (2010), 4 = 4 years ago (2009), 5 = 5 years ago (2008), 6 = before 2008			
T3	Do you know how to implement this technology? 1=Yes, 2=No (if no, skip to **T22** on the next page)			
T3ai	WH: How many centimeters the distance should you dig from the trunk? SG and BG: How many centimeters from the ground the trunk should be grafted?	Cm	Cm	Cm
T3aii	SG and BG only: How long should you wait before removing the plastic cover		Weeks	Weeks
T3aiii	SG and BG only: When do you think is the best time to do the grafting? 1= rainy season 2=dry season 3=others			

T3aiv	WH only: What materials did you use to make wind holes? [Note to Enumerator] If the household chooses manure and some other materials like ash, animal feed leftovers, crop residue, or green manure, please write "1"(meaning the correct knowledge). If the household chooses only manure or manure and some other inappropriate materials like meat, bones, fish scraps, oil, fatty materials, or dairy products, then write "2" (wrong knowledge)			
T4	From where did you learn how to implement this technology:			
T4a	Tanggamus district forestry and agricultural office, development Agents?			
T4b	Farmers group			
T4c	University or school?			
T4e	Traders			
T4f	Relatives			
T4g	Other friends/neighbors?			
T4h	Other organizations, such as NGOs?			
T4i	Others?			
T4j	Internet			
T4k	Farmers who joined the fieldtrip to Tanggamus			
T4l	Farmers who joined the fieldtrip to Kalianda			
T4m	Farmers who joined the fieldtrip to Garut/Ciamis			
T4n	Trainers from Jember during fieldtrip			
		Wind Holes	Side-cleft Grafting	Bud Grafting
	Technology ID	**WH**	**SG**	**BG**
T6	Have you ever used this technology in your farmland? (If No in **T6**, skip to the **next section**) 1=Yes, 2=No			
T6a	If Yes to T6, in which year did you first use this technology? 10= this year (2013) between January – March, 11 = this year (2013) between April – August, 1 = last year (2012), 2 = 2 years ago (2011), 3 = 3 years ago (2010), 4 = 4 years ago (2009), 5 = 5 years ago (2008), 6 = before 2008			
T7	Did you use this technology in the last July or August (ask enumerators about the harvesting time) ? 1=Yes, 2=No			
T7a	If Yes to T6 and No to T7, in which year did you last use this technology? 10= this year (2013) between January – March, 11 = this year (2013) between April – August, 1 = last year (2012), 2 = 2 years ago (2011), 3 = 3 years ago (2010), 4 = 4 years ago (2009), 5 = 5 years ago (2008), 6 = before 2008			
T8	Who was the most influential person in your decision on adoption/disadoption? Choose from **a** to **n** in **T4**			

T11	Where is the most influential person in **T8** living (or working)? 1=Same village, 2=Outside the village but in the same district, 3=Outside the district but in Tanggamus 4=Outside Tanggamus but in Lampung province 5=Outside Lampung			
T11a	How often do you meet the most influential person in **T8**? At least once in every..: 1 = 1 – 2 days, 2= 3 – 14 days, 3= 15 days -1 month, 4 = 2-3 months, 5 = 4 months to 1 year, 6 = more than 1 year			
T11b	Do you know the most influential person well enough so that you could discuss important personal matters with him/her? 1 = Yes 2 = No			
T11c	Do you know the most influential person well enough so that you could borrow Rp. 300,000 from him/her? 1 = Yes 2 = No			
T21a	How many percentages did the yield increases due to adoption of this technology? A negative number is allowed. If you produce more than 1 kind of crop, please answer about the crop for which this technology is used to the largest extent. [Note to Enumerator] You don't have to calculate the percentage of the difference	before after _____ kg=>_____ % **Total**	before after _____kg=>_____ % **Cocoa**	before after _____kg=>_____ % **Coffee**
T22	How many percentages do you think should the yield increases (target) due to adoption of this technology? If you have adopted it, answer what you heard before you adopted it. A negative number is allowed. If you produce more than 1 kind of crop, please answer about the crop for which this technology is used to the largest extent. [Note to Enumerator] Please calculate the percentage increase if the household provides yield before and after adoption.	before after _____ kg=>_____ % **Total**	before after _____kg=>_____ % **Cocoa**	before after _____kg=>_____ % **Coffee**
T24a	SG and BG only: Do you feel there is a decline of pest population such as root-infesting nematodes and seed-infesting caterpillar after implementing bud-grafting and side-cleft grafting? 1 = Yes, 2 = No			
T24b	SG and BG only: Do you think the technologies help improving better yield than local variety, with wider stem diameter, larger fruits and more drought resistance? 1 = Yes, 2 = No			

Section 8. Household Assets

[Enumerator] I would like to ask about your assets. For each of the following items, please answer the number you currently own and provide the estimated current value of the item in total.

Asset		Number of the item currently owned	Total value (Rp) (current value)	**Asset**		Number of items currently owned	Total value (Rp) (current value)
AITEM	**A0**	**A1**	**A3**	**ITEM**	**A0**	**A1**	**A3**
Chicken	1			Car	9		
Duck	2			Motorcycle	10		
Cattle (oxen and cows)	3			Bicycle	11		
Sheep	4			Radio	12		
Goat	5			TV	13		
Buffalo	6			Mobile Phone	14		
Rabbit	7			Others	15		
Fish	8			Others 2	16		

Section 8a. Electronic Goods

H1f. Please tell us about your telecommunication (mobile phone) provider? **H1f** __________
1= Telkomsel 2= Satelindo 3= XL 4= Tri 5= Esia 6= Others

1= Telkomsel	2= Indosat	3= XL	4= Tri (3)	5= Esia	6= Others
1.1 Simpati 1.2 As 1.3 Kartu Halo 1.4 Flash	2.1 Mentari 2.2 IM3				6.1 Flexi 6.2 Axis 6.3 Smartfren

[Enumerator] I would like to ask you some questions about cook stove in your household.

Ba. What type of cook stove do you use currently? Please list all others that apply. (Multiple choices allowed) **Ba** ____________
1=firewood stove 2= oil (kerosene) stove 3=gas stove (single burner) 4=gas stove (double or more burner) 5= Other (Specify)

B1b-1. Have you received the free gas stove from local government?
1=Yes 2=No **Bb-1** ___________

B1b-2. (If answer of question "1c-1" =1(Yes))
When did you receive it? (month / year) **Bb-2** ____/______

(month) (year)

B1c. (If answer of question "1a" = 3=gas stove (single burner) or 4=gas stove (double or more burner))
Which brand do you use currently? Please list all others that apply. (Multiple choices allowed) **B1c** __________
1=RINNAI 2= Quantum 3=TECSTAR 4=Success 5= SANEX 6= Other (Specify)

B1d-1. (If answer of question "1a" =3=gas stove (single burner) or 4=gas stove (double or more burner))
When did you buy it? if you bought on your own. **B1d-1** ___/_____
(month) (year)

Bd-2. **[Note to enumerator]** At question "1d-1", if respondent can't remember, ask another question as below,
Was it before / after election on September 2012?
1=Before the election 2=After the election 3= I'm not sure **B1d-2** _________

[Enumerator] I would like to ask you some questions about probiotic drinks which your household has bought.

B2a. Which brand of probiotic drinks do you usually drink for two weeks? **B2a** __________
1=Yakult 2=Milkuat 3= Calpis 4= Vitacharm 5=Others, mention______ 6= Never

B2b-1. (**Unless** answer of question "2a" =4(Didn't buy at all))
When did you start drinking it? **B2b-1** ___/_____
(month) (year)

[Enumerator] I would like to ask you some questions about toothpaste which your household has bought.

B3a. Which brand of toothpaste do you use currently? Please list all others that apply. (Multiple choices allowed) **B3a** __________
1=Pepsodent 2=Close Up 3=Formula 4=Ciptadent 5=Total Care 6= Other (Specify) 7= Didn't buy at all

B3b-1. (**Unless** answer of question "2a" =4(Didn't buy at all))
When did you start using it? **B3b-1** ___/_____
(month) (year)

Section 9. Geographical Information

[Enumerator] I would like to ask about geographical information. Please answer how many minutes in walking distance it takes to get to the nearest location. Also, where is it located? Please answer the name of the village.

		Minutes	Location
GITEM	**G0**	**G1**	**G2**
Paved road	1		
Unpaved road	2		

Section 10. Personal Ties

[Enumerator] We now ask about your personal relations. First, we will ask whether you know several particular persons. Then, we ask you about the relation with each of the persons. Here, "knowing" has to be mutual. So, if you say you know a person, then, that person should also know you. "Knowing" also means that you can directly contact the person when needed. If you know more than one person, please answer about the closest one.

		Do you know anyone described as below? 1 = Yes 2 = No	Relationship with the person (Enumerator chooses the most appropriate) 1 = Family by blood 2= Family by marriage 3 = Neighbor 4 = Organization member 5 = Work-related 6= Other friend 7 = Other	For how many years have you known this person?	Walking minutes to the person's home (record 999 if out of walking distance)	Main mode of contact 1= Walking/ cycling 2= Private motorized vehicle 3= Public transport 4 = Landline phone call 5 = Mobile phone call	How often do you get in contact with each other (including both phone calls and face-to-face)? [Enumerator chooses] At least once in every..: 1 = 1 – 2 days 2= 3 – 14 days 3= 15 days – month 4 = 2-3 months 5 = 4 months to 1 year 6 = more than 1 year	Ethnicity 1=Javanese 2=Lampung 3=Sumendo 4=Sundanese 5=Sumatra 6=Other 9=I don't know	Religion 1=Muslim 2=Protestant 3=Catholic 4=Hindu 5=Buddhist 6= Other (Specify) 9=I don't know	Do you know this person well enough so that you could discuss important personal matters with him/her? 1 = Yes 2 = No	Do you know this person well enough so that you could borrow Rp. 300,000 from him/her? 1 = Yes 2 = No
	S1	**S2**	**S3**	**S101**	**S4**	**S5**	**S6**	**S7**	**S8**	**S102**	**S103**
An extension agent	3										
Person who goes to the Java Island at least 2x/ year	8										
Trainers from Jember	12										
Farmers/contact in Java island during fieldtrip	13										
Farmers/contact in Kalianda during fieldtrip	14										

Section 12. Cocoa and Coffee Information Network

[Enumerator] Sometimes farmers like to discuss with other people about their crop yields, particularly about coffee and/or cocoa. I will ask you now about such people. Please list for all people that you can recall from outside of this household that you seek for advice, you can learn from, or who can generally provide useful information, regarding farming practices. Please provide the information about the head of the household, even if the person you have in mind is not the household head.

[Note to the enumerator] First, fill in the all the full names of all household heads of the persons that the respondent recalls (but no more than 20) before asking other information .After all the names have been obtained, fill in the additional information for each head. It is **extremely important** that you identify the HHID of all listed heads from the same **ZONE** and check with the respondent that it is correct!

Counter	First Name	Second Name	Relationship with the person (Enumerator chooses the most appropriate) 1 = Family/ relative 3 = Neighbor 4 = Farmers group member 5 = Know through government institution 6= Know/meet during the training in April 2013 7 = Other	For how many years have you known this person?	Main mode of contact 1= walking/ cycling 2= private motorized vehicle 3= public transport 4 = landline phone call 5 = mobile phone call 6=Horse(cart)	How often do you usually meet with this person? [Enumerator chooses At least once in every..: 1 = 1 – 2 days 2= 3 – 14 days 3= 15 days – month 4 = 2-3 months 5 = 4 months to 1 year 6 = more than 1 year	Did he join the fieldtrip in April and where? 1=Yes in Tanggamus 2=Yes in Kalianda 3= Yes in Garut/ Ciamis 4= No 9=Don't know	Does he/she come from the same farmers group? 1= Yes 2= No 9= Don't know	Ask the followings if the answer to N8 is 1, Is s/he the household head? 1 = Yes 2= No	First name of the head	Full HHID	Ask the followings if the answer to N8 is2 Does s/he: 1= lives in the same *Dusun* 2= lives in different *Dusun* but same Village 3= lives in different Village but same sub-district 4= lives in different sub-district but in Tanggamus 5=lives outside Tanggamus
			N4	**N5**	**N6**	**N7**	**N15**	**N8**	**N10**	**N11**	**N13**	**N14**
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												

Section 15. Social Preference

[Enumerator] Now, I will ask questions about what you would do under some hypothetical situations.

R2 Suppose that the government will give you either Rp. 500,000 1 month from now or Rp. 1,000,000 1 year from now. Which would you like to choose?
(1) Rp. 500,000 month from now (2) Rp. 1,000,000 1 year from now **R2** ____________

R5 Generally speaking, would you say that most people can be trusted? 1 = Yes, 2 = No **R5** ____________

R6 Would it be acceptable to you if your daughter or female relative would marry a man whose religion is different from you? 1 = Yes, 2 = No **R6** ____________

R7 Would it be acceptable to you if your daughter or female relative married a man whose ethnicity is different from you? 1 = Yes, 2 = No **R7** ____________

Section 16. Ethnicity

[Enumerator] In this country, people come from many different places, say islands, and cultures, and there are many different words to describe the different backgrounds or ethnic groups that people come from. These questions are about your ethnicity or your ethnic group and how you feel about it or react to it.

[Note for enumerator]
To answer the questions of ETA1, ETA2 and ETA3, please choose only one answer from BOX-1 below. If farmers think they belong to more than one ethnicity, please ask them the most suitable ethnicity they thing they most belong to. If the answer is (9), please ask them the ethnicity name.

[BOX-1] Answers for questions ETA1, ETA2, dan ETA3		
(1) Java	(2) Lampung	(3) Sunda
(4) Sumendo	(5) Batak	(6) Bali
(7) Madura	(8) Minang	(9) Others (⇒mention, ____________________)

This is the end of part A. Please move to part B.

ETA1	What ethnicity do **You** belong to?............	
ETA2	What ethnicity does **Your Mother** belong to?............	
ETA3	What ethnicity does **Your Father** belong to?............	
ETA4	What ethnicity does **Your Wife** belong to?............	

[Note for enumerator]
For the questions below, please listen to the statements and answer whether you agree or disagree to each statement. Please use following scale: **(4) Strongly agree, (3) Agree, (2) Disagree, and (1) Strongly disagree,** to show how much you agree or disagree to each statement. If respondent answers agree or disagree, please ask whether they strongly agree/disagree or just agree/disagree to some extent.

(4) Strongly agree, (3) Agree, (2) Disagree, and (1) Strongly disagree

ETB1	I have spent time trying to find out more about my ethnic group, such as its history, traditions, and customs………	(4) — (3) — (2) — (1)
ETB2	I am active in organizations or social groups that include mostly members of my own ethnic group………………	(4) — (3) — (2) — (1)
ETB3	I have a clear sense of my ethnic background and what it means for me…………………………………………..	(4) — (3) — (2) — (1)
ETB4	I think a lot about how my life will be affected by my ethnic group membership………………………………….	(4) — (3) — (2) — (1)
ETB5	I am happy that I am a member of the group I belong to………………………………………………………….	(4) — (3) — (2) — (1)
ETB6	I have a strong sense of belonging to my own ethnic group………………………………………………………….	(4) — (3) — (2) — (1)
ETB7	I understand pretty well what my ethnic group membership means to me…………………………………………….	(4) — (3) — (2) — (1)
ETB8	In order to learn more about my ethnic background, I have often talked to other people about my ethnic group……	(4) — (3) — (2) — (1)
ETB9	I have a lot of pride in my ethnic group……………………………………………………………………………….	(4) — (3) — (2) — (1)
ETB10	I participate in cultural practices of my own group, such as special food, music, or customs………………………..	(4) — (3) — (2) — (1)
ETB11	I feel a strong attachment towards my own ethnic group………………………………………………………………..	(4) — (3) — (2) — (1)
ETB12	I feel good about my cultural or ethnic background…………………………………………………………………..	(4) ・ (3) ・ (2) ・ (1)

This is the end of part B. Please continue to part C.

[Catatan untuk Enumerator] Choose and circle ONLY ONE from the choices of answers in BOX-2 for ETC1. If the answer from farmers are not available in the box, please choose (9) and specify.

ETC1 What is your main language that you most frequently use? Please choose from the choices below.........
(If the answer is [(9) Others] please ask respondent the language they most frequently use)

(1) Bahasa Indonesia	**(2) Lampungnese language**	**(3) Javanese language**	**(4) Sundanese language**	**(5) Sumendonese language**
(6) Balinese language	**(7) Bataknese language**	**(8) Maduranese language**	**(9) Others (Mention)**	

If the answer from ETC1 is (1) Bahasa Indonesia ⇒continue to ETC5

If the answer from ETC1 **IS NOT** (1) Bahasa Indonesia ⇒continue to ETC2

To answer the following questions, please use the numbers below to indicate the mastery of the language:
(5) Very well (4) Well (3) Just OK (2) Poor (1) Very poor

ETC2	In your opinion, how well do you speak in your main language?......	(5)—(4)—(3)—(2)—(1)
ETC3	In your opinion, how well do you write in your main language (including writing in the traditional alphabets)?......	(5)—(4)—(3)—(2)—(1)
ETC4	In your opinion, how well do you read in your main language (including reading the traditional alphabets)?......	(5)—(4)—(3)—(2)—(1)
ETC5	In your opinion, how well do you speak in Bahasa Indonesia?......	(5)—(4)—(3)—(2)—(1)
ETC6	In your opinion, how well do you write in Bahasa Indonesia?......	(5)—(4)—(3)—(2)—(1)
ETC7	In your opinion, how well do you read in Bahasa Indonesia?	(5)—(4)—(3)—(2)—(1)

[Enumerator] Thank you very much for your assistance. This is the END of the survey.

[Note to the Enumerator] On a scale of 0 to 10, rate the respondent's level of cooperation during the interview. **CO** ___________

0…not cooperative at all, 10…extremely cooperative

Part III

APPENDIX

BUDIDAYA TANAMAN KOPI

TUJUAN MAKRO

. Lingkungan
. Sosial
. Ekonomi

↓

KEUNTUNGAN LESTARI

KEUNTUNGAN LESTARI

1. PEMASARAN
   - Permintaan & Penawaran
   - Selera konsumen
   - Daya Beli
2. KOMPETITIF/HARGAan POKOK RENDAH
   - Efektif d Efisien
   - Kuantitas dan Kualitas Hasil

PENERAPAN FUNGSI MANAGEMEN

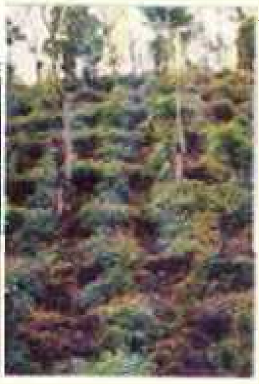
CIRI-CIRI LAHAN YANG DINILAI

No.	Ciri-ciri	Kelas kesesuaian lahan untuk kopi			
		S1	S2	S3	N
1	c. Iklim:				
	Curah hujan tahunan (mm)	1500-2000	1250-1500,2000-2500	1000-1250,2500-3000	<1000, >3000
	Lama bulan kering (bulan)	2-3	3-4	4-5	>5
2	t. Elevasi (m dpl.)				
	Robusta	300-500	500-600 100-300	600-700 0-100	>700
	Arabika	1000-1500	850-1000 1500-1750	650-850 1750-2000	<650 >2000
3	s. Lereng (%)	0-8	8-25	15-45	>45 (>24°)
4	r. Sifat fisik tanah:				
	Kedalaman efektif (cm)	>150	100-150	60-100	<60
	Persen batuan di permukaan (%)	-	0-3	3-15	>15

(LANJUTAN)

No.	Ciri-ciri	Kelas kesesuaian lahan untuk kopi			
		S1	S2	S3	N
5	n. Sifat kimia tanah (0-30 cm):				
	pH	5.5-6.0	6.1-7.0, 5.0-5.4	4.0-4.9, 7.1-8.0	<4.0, >8.0
	C-organik (%)	2-5	1-2, 5-10	0.5-1, 10-15	<0.5, >15
	N	Sedang-sangat tinggi	Rendah	Sangat rendah	-
	P	-idem-	-idem-	-idem-	-
	K	-idem-	-idem-	-idem-	-

PERSIAPAN LAHAN



PENANAMAN POHON PENAUNG

PENANAMAN POHON PENAUNG

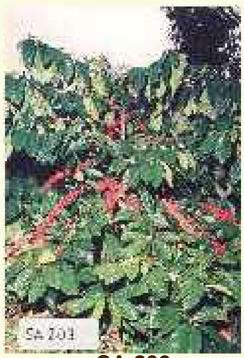
PERSIAPAN BAHAN TANAM

Klon Kopi Robusta Generasi I

BP 358

BP 288

Klon Kopi Robusta Generasi II (Sesuai Untuk Daerah Iklim Kering)



SA 203

BP 939

Klon Kopi Robusta Generasi II (Adaptasi Luas)

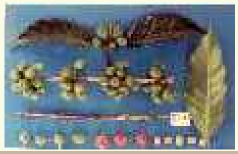
BP 936

BP 534

Klon Kopi Robusta Generasi II (Sesuai Untuk Daerah Iklim Basah)

ArabikaS 795

- Arabika tipe tinggi
- Dapat beradaptasi pada kondisi lahan marginal
- Protas mencapai 2 ton/ha untuk populasi 1600 pohon/ha
- Biji kopi kurang tahan disimpan lama
- Saran penanaman > 700 m dpl.
- Daun hijau tua gelap, pupus coklat.
- Percabangan rimbun tidak teratur, buah tersembunyi
- Buah diskusnya melebar, warna buah muda hijau kotor



Kartika 1

- Arabika tipe katai
- Protas > 2,5 ton/ha untuk populasi 2500 pohon/ha
- Rentan karat daun kopi
- Rentan nematoda : *Pratylenchus* sp. & *Radopholus similis*
- Saran penanaman : > 1000 m dpl., tanah subur.
- Daun hijau tua tebal, pupus daun hijau, berbentuk oval
- Buah kecil membulat, dompolan buah rapat.

VARIETAS ANDUNGSARI (Kopi Arabika)

Asal	:	Populasi keturunan CIFC H-440
Biji	:	agak kecil, memanjang
Dayahasil	:	3,5 ton/ha populasi 3.300 ph/ha
Citarasa	:	Baik

Terhadap karat daun:
Tahan (>1000 m dpl.),
Agak tahan (<900 m dpl.)

PENYIAPAN BENIH TANAMAN KOPI

- Petik buah merah
- Pengupasan kulit buah
- Penghilangan lendir
- Pengeringan anginan
- Pengepakan benih

PENYEMAIAN BENIH KOPI

- Pengupasan kulit
- Pendederan
- Penyiraman
- Pemeliharaan

PENGISIAN DAN PENANAMAN DI POLIBAG

KLONALISASI

SAMBUNG DINI

SAMBUNG DEWASA

PENYETEKAN

PENANAMAN

KONDISI TANAMAN KOPI PADA AREAL ENDEMIK NEMATODA

Arabika Kartika I

Robusta BP 42

KOPI ROBUSTA KLON BP 308

Kopi Robusta Klon Selain BP 308 di Daerah Endemik Nematoda

Kopi Robusta Klon BP 308 di Daerah Endemik Nematoda

Perbandingan Perakaran Kopi Klon BP 308 vs BP 42

BP 308 vs BP 42

PEMUPUKAN

• ORGANIK
•ANORGANIK

Agar pemupukan tanaman kopi efisien, maka dalam pemupukan perlu memegang 4 prinsip agar serapan hara pupuk maksimal dan kehilangan hara pupuk minimal, yaitu:

1. Tepat dosis
2. Tepat jenis
3. Tepat cara aplikasi
4. Tepat waktu

PUPUK ORGANIK

Mutu pupuk :

- ❑Tergantung tingkat kematangan
- ❑Paling baik diberikan dalam bentuk sudah cukup matang (kompos), C/N < 20.

Mutu hara tergantung sumber :

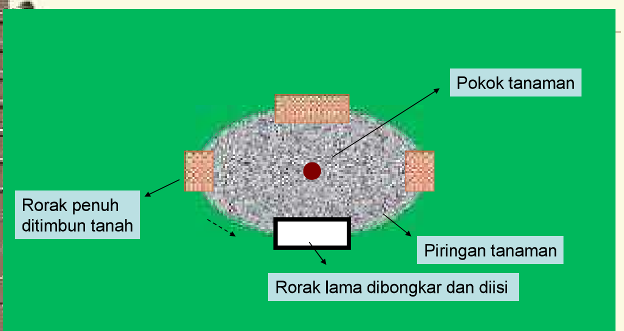
- ❑Jenis vegetasi
- ❑Jenis ternak

Nilai Hara Pupuk Kandang Beberapa Ternak

Ternak	Kadar air	N	P	K
	……………..	% (Thd. berat kering)	……..………..	
Sapi	80	1.67	0.48	0.46
Domba	68	3.75	0.82	1.04
Kuda	75	2.29	0.55	1.15
Ayam	56	6.27	2.58	2.71
Merpati	52	5.68	2.50	2.68
Babi	82	3.75	0.82	1.04

Sumber : Gaur (1981)

APLIKASI PUPUK ORGANIK



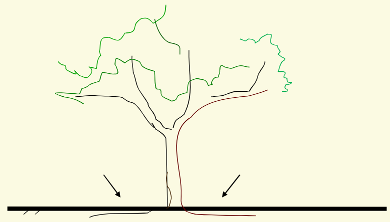
Gambar 10. Pembongkaran rorak dan menebarkan isinya di piringan tanaman, bergantian mengelilingi pokok kopi dan diisi seresah baru

Gambar 12. Pada lahan datar, rorak dibuat di antara barisan tanaman pokok

DOSIS PUPUK TENTATIF KOPI

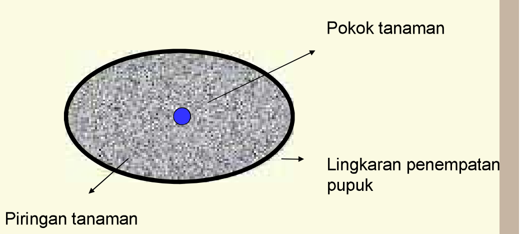
Umur/ Fase	Satuan	Urea	SP-36	KCl	Kiserite
Bibit	g/bibit	-	-	-	-
0-1 th	g/ph/th	40	50	30	20
1-2 th	id	100	80	80	30
2-3 th	id	150	100	100	50
3-4 th	id	200	100	140	70
>4 th	id	300	160	200	100

APLIKASI PUPUK ANORGANIK



Gambar 2. Pemupukan di lapangan pada jarak 50-75 cm dari pokok

APLIKASI PUPUK ANORGANIK



Gambar 3. Penempatan pupuk dalam galian sedalam 5-10 cm mengelilingi pokok kopi pada jarak 50-75 cm

PENGENDALIAN GULMA

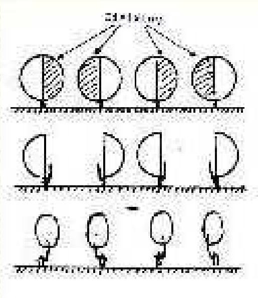
1. CARA KIMIA
2. CARA MANUAL

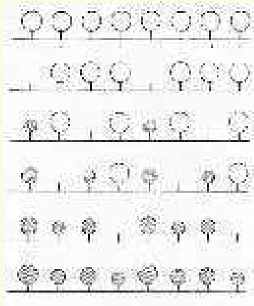
CARA KIMIA


CARA MANUAL

Tanaman Kopi Tua
(Perlu perbaikan)

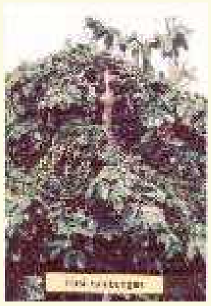
Rehabilitasi Tanaman Kopi



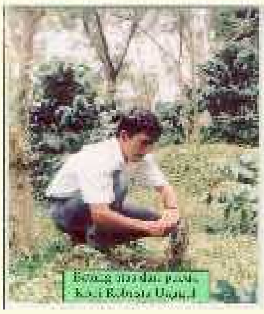


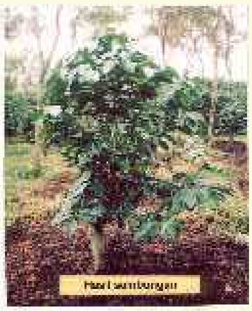
Cara Penyambungan Pada Kopi

Rehabilitasi Kopi
dengan Sambung Cabang



Rehabilitasi Kopi
Dengan Sambung Pucuk





PANGKASAN TANAMAN KOPI DAN TOKOK POHON PENAUNG

- ✓ Mengapa harus dipangkas
- ✓ Bagaimana dikerjakan
- ✓ Kapan dilaksanakan

Sifat pertumbuhan tanaman kopi

- Dimorfisme pertumbuhan
  - Orthotropik (tegak, vertikal)
  - Plagiotropik (mendatar, horisontal)
- Macam tunas dan cabang
  - Legitim (hanya satu): primer, skundair, kipas
  - Seri (reproduksi,4-5 bh): wiwilan, balik, liar, cacing,
- Pola pembuahan cabang
  - Buah pada buku cabang, umumnya hanya sekali
  - Makin tua cabang, buah makin berkurang dan kecil-kecil

BEBERAPA MACAM CABANGAN TANAMAN KOPI

Tujuan pokok:
Menyediakan cabang-cabang produktif secara optimal sesuai kondisi dan dayadukung tanaman

Manfaat:

1. Memperkecil fluktuasi produksi dan risiko kerusakan over-bearing dieback
   ☛ Tanaman sehat, produksi stabil
2. Membantu penyebaran cahaya dan peredaran udara
   ☛ Pembungaan merata, penyerbukan lancar
3. Memudahkan pengendalian HP dan meningkatkan efisiensi dan efektifitas pestisida
4. Mengurangi dampak kekeringan
5. Memudahkan perawatan dan panen

Sistem pangkasan kopi
1. Batang Tunggal
2. Batang ganda

Memilih sistem pangkasan
- Kondisi Lingkungan
- Ketersediaan Tenaga/Dana
  ☛ Pelaksanaan lebih cepat & sederhana
- Jenis/varietas (pertunasan arabika lebih aktif)
  ☛ Pemeliharaan tanamn bersifat individual, Kemudahan penanganan sangat penting

KEUNGGULAN KOMPARATIF PANGKASAN Bt.TUNGGAL & Bt. GANDA

Keunggulan BT:
- Tanaman lebih kokoh
- Reproduksi primer & skunder lebih aktif
- Tdk perlu rejuvinasi periodik
- Pemanenan lbh mudah
- Lbh tahan peng.cabang
- Umur produktif lebih panjang

Keunggulan BG
- Lebih cepat & mudah
- Tdk perlu terampil
- Sinar lebih merata,
- Pertumbuhan skunder tdk seaktif Bt tunggal
- Buah relatif lebihbesar karena dihasilkan cab. primer (yg sehat)

KEUNGGULAN KOMPARATIF PANGKASAN Batang TUNGGAL dan Batang GANDA

Kelemahan BT
- Pelaksanaan > sulit & lama
- Perlu terampil
- Pengaturan tajuk > rumit
- Peredaran udara & sinar lebih sukar diatur bila tidak konsisten
- Pertunasan lebih aktif, (cab. balik, cb. Liar dsb.)

Kelemahan BG
- Rentan penggerek cbg.
- Mudah rusak krn angin
- Kurang cocok utk tan. tua
- Pemanenan lebih sulit bila telah tua (tinggi)
- Batang kurang kokoh
- Umur produktif > singkat

Sistem Batang Tunggal

Pangkas bentuk
- **Tujuan:**
  Membentuk kerangka pohon yang kuat & seimbang untuk mempermudah pelaksanaan pemangkasan selanjutnya.
- **Waktu pelaksanaan: TBM-1, awal musim hujan**
- **Teknik pelaksanaan:**
  - ✓ **Sistem Etape /"tangan" (unit percabangan cabang produktif) dan**
  - ✓ **Sistem Bayonet (wiwilan yang ditumbuhkan setelah batang pokok dipotong)**

TAHAPAN PANGKASAN BENTUK

PENAMPILAN TANAMAN SETELAH DIPANGKAS BENTUK

PANGKASAN BENTUK YANG TERLAMBAT

Teknik pangkas bentuk

Sistem 2-etape
- Etape-1 : 120 cm
- Etape-2 : 160 cm

BT dengan sistem 2-etape

Keunggulan sistem 2-etape

✓ Intensitas cahaya lebih merata keseluruh segmen tajuk. Potensi pembungaan & pembuahan lbh baik.
- ☛ Hasil per pohon tidak beda dengan 3-etape

✓ Pelaksanaan lebih cepat, cabang lebih sedikit
- ☛ Kebutuhan tenaga berkurang

✓ Struktur tajuk lebih ramping
- ☛ Efektivitas jarak tanam tetap optimal

Pelaksanaan PLP

- Prinsip Seawal mungkin selesai panen
  Pertum. ruas 3- 4 minggu (Mh), 6-8 minggu (Mk)
- Memotong cabang tidak produktif,
  lemah, kering, terserang hp, berbuah > 2-3 kali

Sept-Okt → PLP selesai
3 bulan I
Jan-Feb → Seleksi cab. baru
3 bulan II
Mar-Apr/Mei → Wiwil halus

(Pada Juni/Juli kadang perlu wiwil halus lagi agar pohon tidak terlalu rimbun)

Sistem batang Ganda

- **Bahan tanam sehat:**
  - **Tahan nematoda /penyakit akar**
  - **Tahan karat daun, HV (arabika)**
- **Perioritas lahan baik (S1>S2)**
  - **Tanah subur/cukup hara,**
  - **Elevasi diatas 1000 m (arabika)**
  - **Curah hujan dan Intensitas cahaya cukup**

Sistem batang Ganda

Pangkas bentuk

- **Tujuan**:
  Membentuk tunggul penyangga bagi 3-4 wiwilan (tunas batang) yang letaknya menyebar pada batang pokok (Tahap awal hanya 2 batang)
- **Waktu pelaksanaan: TBM-1, awal musim hujan**
- **Teknik pelaksanaan:**
  Memotong batang pokok pada tinggi ± 50 cm dari permukaan tanah

Pemangkasan produksi

- **Memotong cabang primer tidak produktif (cabang lemah, balik, menggantung, kering, terserang hama- penyakit, berbuah >3 kali,**
- **Mengurangi primer yang tumbuh di bagian dalam tajuk**
- **Peremajaan batang yang telah tua**

Peremajaan batang (rejuvinasi)

- **Metode Hawaii**
  Peremajaan batang bergantian dalam satu pohon
  - **Modifikasi: memotong secara bersamaan kecuali satu sebagai paru-paru tanaman untuk menghindari resiko kematian batang pokok**
- **Metode Beaumont-Fukunaga**
  Peremajaan berdasarkan barisan tanaman kopi ☛ Umumnya dengan rumus 1324
- **Metode IPS (Ijen Pruning System)**
  - **Modifikasi BF: Peremajaan berdasarkan blok pertanaman kopi**

Teknik peremajaan batang kopi arabika
(modifikasi metode hawaii)

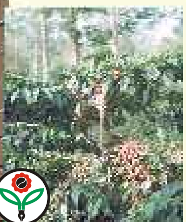
IPS Kopi Arabika
di Pegunungan Ijen

PENYEDIAAN CABANG BUAH dan POTENSI PRODUKSI

Target PLP:

Cabang buah produktif: B1 & B2

Proporsi cabang: 1/3 B1; 1/3 B2; 1/3 Bv



Potensi produksi tergantung

- Umur/Habitus Tanaman
- Kerangka percabangan & Komposisi jenis cabang
- Kesehatan Tanaman (Pemeliharaan, lingkungan)

Perhitungan matematis kebutuhan B1 & B2 untuk 1 kg kopi biji/ph

Kondisi Percabangan Selesai PLP dan seleksi wiwil

Komponen produksi	B1	B2	Bv	B3
Robusta				
Jumlah buah/dompol	15	10	-	4
Jml dompol/cabang	8-10	6-8	-	3-5
Jml buah/cabang	120-150	60-80	-	12-20
Produksi/cabang (kg)	-	-	-	-
Prod.B1+B2(kg)		-	-	
Jml Cabang/ph	17,1	17,1		17,1
Rendemen 20%, bh/kh 700				

Perhitungan matematis kebutuhan B1 & B2 untuk 1 kg kopi biji/ph

Kondisi Percabangan Selesai PLP dan seleksi wiwil

Komponen produksi	B1	B2	Bv	B3
Arabika				
Jumlah buah/dompol	10	8	-	3
Jml dompol/cabang	8-10	6-8	-	3-5
Jml buah/cabang	80-100	48-64	-	9-15
Produksi/cabang (kg)	-	-	-	-
Prod.B1+B2(kg)=0,03				
Jml Cabang/ph	34,2	34,2		34,2
Rendemen 14%, bh/kh 700				

Kondisi Percabangan Selesai PLP (robuta) (Sept/Oktober)

- **20-30 B1**
- **20-30 B2**
- **Beberapa B3 & Bv yang telah tumbuh (diabaikan)**

Kondisi Selesai Wiwil Seleksi (Jan/Peb)

- **Cabang berbuah (B1 & B2) : 40-60 cabang**
- **Cabang Bv : 20-30 cabang**
- **Jumlah cabang/pohon : 60-90 cabang**

Perkiraan Produksi : 1,17 – 1,75 kg/ph

Protas (populasi 90% standar): 1500 – 2000 tan/ha

APA YANG PERLU DIPERHATIKAN ?

- Pemangkasan memegang peran sangat penting dlm proses produksi budidaya kopi yang sehat.
- Agar pemangkasan berhasil baik perlu pemahaman dasar-dasar pangkasan secara baik.
- Pemilihan sistem pangkasan perlu mempertim-bangkan kondisi lingkungan, ketersediaan biaya & tenaga serta jenis kopi yang diusahakan .
- Keberhasilan pangkasan perlu didukung tindakan kultur teknik lain, seperti pengaturan penaung, perbaikan kesuburan tanah, dan pengendalian HP

PENGELOLAAN PENAUNG KOPI

PERLUKAH DITOKOK

PENGURANGAN POHON PENAUNG

KEGIATAN TOKOKAN PENAUNG KOPI

PELAKSANAAN
- AWAL HUJAN
- PENGURANGAN PENAUNG 50 % UMUR 3-4 TAHUN
- TOKOK 50 % TIAP TAHUN
- REMPESAN AWAL KEMARAU

TANAMAN KOPI TANPA PENAUNG

DIVERSIFIKASI TANAMAN KOPI

Intercrop dengan Kelapa

Intercrop dengan Jeruk

INTEGRASI KOPI DENGAN DOMBA

DIVERSIFIKASI TANAMAN KOPI

Intercrop dengan Pisang

Intercrop dengan Rumput Gadjah

DIVERSIFIKASI TANAMAN KOPI

Diversifikasi dgnTernak

Pupuk kandang sangat diperlukan tanaman

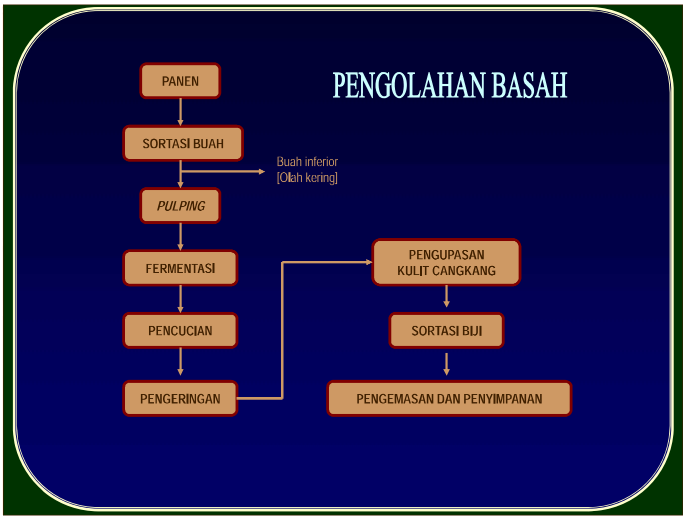
PANENAN

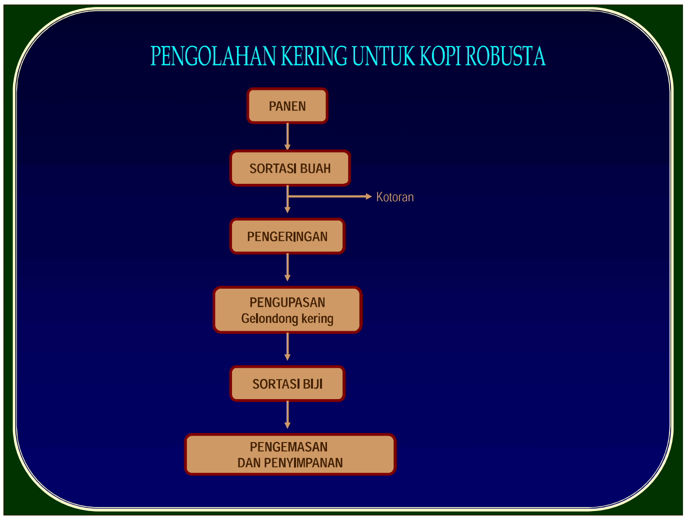
- ✓ Diawali dengan panen bubuk
- ✓ Buah kopi dipetik berwarna merah
- ✓ Harus dihindari pemetikan buah kopi yang masih hijau atau kuning
- ✓ Diakhiri dengan panen racutan dan lelesan

PENGOLAHAN KOPI

Ada dua cara pengolahan buah kopi :

- ✓ Pengolahan cara kering
- ✓ Pengolahan cara basah
- ✓ Perbedaan kedua cara tersebut adalah adanya penggunaan air yg diperlukan untuk pengupasan maupun pencucian buah kopi





Kebijakan Pengembangan Kopi

PEMERINTAH KABUPATEN GARUT
DINAS PERKEBUNAN
Jalan Pembangunan Nomor 181 Garut
perkebunan@garutkab.go.id

KOPI DI KABUPATEN GARUT

PENANAMAN KOPI DI PASUNDAN DILAKUKAN SEJAK TAHUN 1720 MELALUI SISTEM *PREANGER STELSEL*
(Jan Breman 2010)

WILAYAH PENANAMAN TERUTAMA BERADA DI WILAYAH PRIANGAN

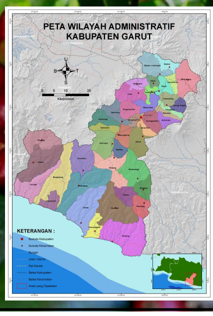
KOPI YANG DIHASILKAN DIKENAL SEBAGAI
PREANGER KOFFIE

PENYEBARAN DAN VARIETAS

TERSEBAR DI 27 KECAMATAN , YAITU : CIKAJANG, CISOMPET, CISEWU, SAMARANG, SUKARESMI, TALEGONG, PASIRWANGI, CISURUPAN, CARINGIN, CIGEDUG, CILAWU, BUNGBULANG, BAYONGBONG, MALANGBONG, KARANGPAWITAN, SUKAWENING, KARANGTENGAH, BANJARWANGI, PEUNDEUY, PAMULIHAN, PAKENJENG, CIHURIP, LELES, KADUNGORA, SELAAWI, CIKELET DAN GARUT KOTA

VARIETAS YANG DITANAM:
ROBUSTA DAN ARABIKA

LUAS PENANAMAN 3.516 HEKTAR DENGAN PRODUKSI DAN PRODUKTIVITAS MENCAPAI 1.685 TON DAN 0,92 TON/HEKTAR
(Data Statistik Perkebunan 2012)



LUAS TANAMAN DAN PRODUKSI

TAHUN	LUAS AREAL				PRODUKSI (TON)
	TBM	TM	TT/TR	JUMLAH	
2008	721	641	185	1.547	508,00
2009	1.092	833	185	2.110	670,00
2010	1.376	1.785	275	3.436	1.592,00
2011	1.379	1.777	335	3.491	1.635,00
2012	1.354	1.827	335	3.516	1.685,00

DATA 5 TAHUN TERAKHIR MENUNJUKAN TREN PENINGKATAN AREAL PERTANAMAN

MENUNJUKKAN TINGGINYA ANIMO MASYARAKAT UNTUK MEMBUDIDAYAKAN KOPI

PROSPEK KOMODITI KOPI

- BERDASARKAN KEBIJAKAN PENGEMBANGAN KOMODITI PERKEBUNAN, TANAMAN KOPI MERUPAKAN SALAH SATU KOMODITI PERKEBUNAN YANG MENDAPAT PERHATIAN UNTUK DIINTENSIFKAN DALAM PENGEMBANGANNYA.
- ADA 2 (DUA) JENIS TANAMAN KOPI YANG MEMILIKI NILAI EKONOMIS CUKUP TINGGI, YAITU : *ARABIKA DAN ROBUSTA*
- KOPI ARABIKA DIPASARAN DUNIA DIBEDAKAN MENJADI 3 (TIGA) KELOMPOK YAITU :

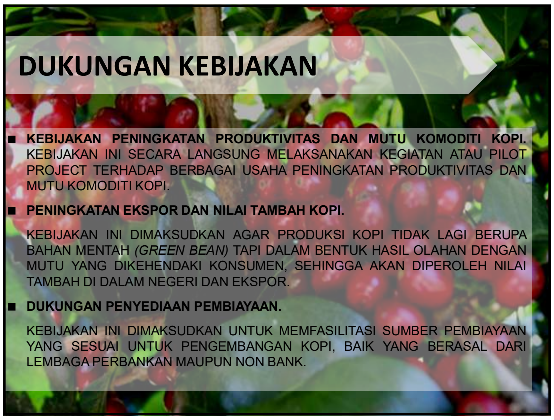
  1). KOPI ARABIKA BIASA/KOMERSIAL (*REGULAR/COMMERCIAL*),
  2). KOPI SPESIALTI (*SPESIALTY*) DAN
  3). KOPI ORGANIK
- KOPI SPESIALTI MERUPAKAN JENIS KOPI YANG TERBAIK CITARASANYA DAN MEMPUNYAI CITARASA BERSIFAT KHAS, KARENA ITU PASARANNYA JUGA KHUSUS

PROSPEK KOMODITI KOPI

- PANGSA PASAR KOPI SPESIALTI MASIH TERBUKA, TERUTAMA DENGAN BERGESERNYA KONSUMEN KOPI BIASA KE KOPI SPESIALTI, HAL INI MERUPAKAN PROSPEK YANG SANGAT BAIK UNTUK PENGEMBANGAN TANAMAN KOPI.
- KOPI ARABIKA SPESIALTI DARI INDONESIA SAAT INI ANTARA LAIN :

  1. *MANDAILING COFFEE*
  2. *LINTONG COFFEE*
  3. *GAYO MOUNTAIN COFFEE*
  4. *JAVA ARABIKA COFFEE*
  5. *BALI COFFEE*
  6. *TORAJA KALOSI COFFEE*
- UNTUK PENGEMBANGAN KOPI ROBUSTA MASIH TERBATAS PADA LAHAN-LAHAN DATARAN RENDAH SAMPAI SEDANG YANG MEMPUNYAI KETINGGIAN 0 - 600 METER DI ATAS PERMUKAAN LAUT.


PERMASALAHAN
■ RENDAHNYA TINGKAT PRODUKTIVITAS DAN PRODUKSI DAN PRODUKSI KOPI DISEBABKAN KARENA KEBANYAKAN DIUSAHAKAN OLEH PERKEBUNAN RAKYAT SECARA TUMPANGSARI DAN BELUM MENERAPKAN TEKNIK BUDIDAYA TANAMAN KOPI SESUAI DENGAN ANJURAN TEKNIS, KESADARAN PETANI AKAN BENIH UNGGUL BERMUTU MASIH RENDAH, TANAMAN KOPI SUDAH TUA / RUSAK DAN MENINGKATNYA SERANGAN HAMA / PENYAKIT TANAMAN.
■ SEBAGIAN BESAR KOMODITI KOPI, BARU DIOLAH DALAM BENTUK BIJI KOPI BERASAN, SEDANGKAN PENGOLAHAN PRODUK HILIRNYA BELUM DILAKUKAN SECARA INTENSIF, SEHINGGA PELUANG UNTUK MEMPEROLEH NILAI TAMBAH (ADDED VALUE) SERTA PENCIPTAAN LAPANGAN PEKERJAAN DI PEDESAAN KURANG OPTIMAL.
■ KOMODITI KOPI MEMBERIKAN KONTRIBUSI LAPANGAN KERJA BAGI SEKITAR 6.536 KK DI KABUPATEN GARUT DAN MAMPU MENDORONG PERKEMBANGAN EKONOMI WILAYAH TERSEBUT.


DUKUNGAN KEBIJAKAN
■ KEBIJAKAN PENINGKATAN PRODUKTIVITAS DAN MUTU KOMODITI KOPI. KEBIJAKAN INI SECARA LANGSUNG MELAKSANAKAN KEGIATAN ATAU PILOT PROJECT TERHADAP BERBAGAI USAHA PENINGKATAN PRODUKTIVITAS DAN MUTU KOMODITI KOPI.
■ PENINGKATAN EKSPOR DAN NILAI TAMBAH KOPI.
KEBIJAKAN INI DIMAKSUDKAN AGAR PRODUKSI KOPI TIDAK LAGI BERUPA BAHAN MENTAH (GREEN BEAN) TAPI DALAM BENTUK HASIL OLAHAN DENGAN MUTU YANG DIKEHENDAKI KONSUMEN, SEHINGGA AKAN DIPEROLEH NILAI TAMBAH DI DALAM NEGERI DAN EKSPOR.
■ DUKUNGAN PENYEDIAAN PEMBIAYAAN.
KEBIJAKAN INI DIMAKSUDKAN UNTUK MEMFASILITASI SUMBER PEMBIAYAAN YANG SESUAI UNTUK PENGEMBANGAN KOPI, BAIK YANG BERASAL DARI LEMBAGA PERBANKAN MAUPUN NON BANK.


DUKUNGAN KEBIJAKAN
■ PEMBERDAYAAN PETANI.
◇ PENUMBUHAN DAN PENGUATAN KELEMBAGAAN USAHA TANI.
◇ PELATIHAN DAN PENDAMPINGAN UNTUK MENINGKATKAN KEMAMPUAN PETANI DAN KELOMPOK TANI DALAM PEMANFAATAN PELUANG BISNIS.
◇ MENUMBUHKAN DAN MENGEMBANGKAN KEMITRAUSAHAAN.


TERIMA KASIH

BAHAN TANAM UNGGUL KAKAO dan PERBANYAKANNYA

Hendro Winarno

PUSAT PENELITIAN KOPI DAN KAKAO INDONESIA
Jl. PB. Sudirman 90 Jember, Telp: (0331) 757130, 757131.
Email: iccri@iccri.net , www.iccri.net

Sistematika Tanaman Kakao

Divisio	:	Spermatophyta
Subdivisio	:	Angiospermae
Klas	:	Dicotyledoneae
Subklas	:	Dialypetalae
Ordo	:	Malvales
Familia	:	Sterculiaceae
Genus	:	Theobroma
Species	:	*Theobroma cacao, L*

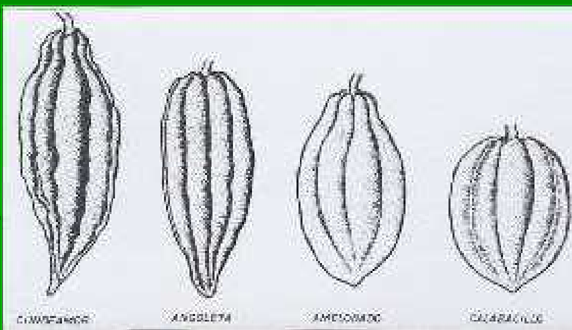
Berdasarkan Tipe Populasi

Tipe Criollo : Buah warna merah, kulit buah kasar, biji putih, kurang tahan OPT

Tipe Forastero : Buah warna hijau, kulit buah halus, biji ungu, lebih tahan OPT

Tipe Trinitario : Criollo x Forastero (alami), sifat antara keduanya

Berdasarkan Bentuk Buah



Berdasarkan Aspek Perdagangan

Kakao Mulia, Kakao Edel

(*Fine flavour cocoa*)

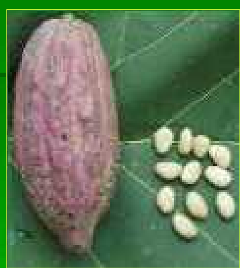
Biji dengan daun kotil berwarna putih dihasilkan dari tipe criollo atau trinitario

---

Kakao Lindak, Kakao Bulk

(*Bulk cocoa*)

Biji dengan daun kotil berwarna ungu dihasilkan dari tipe forastero atau trinitario



Kakao Mulia

Biji putih

Kakao Lindak

Biji Ungu

PENGERTIAN
BAHAN TANAM vs BAHAN TANAMAN

- Bahan tanam : *(PLANTING MATERIAL)* klon, hibrida, , lini murni, varietas, komposit, sintetik.
- Bahan tanaman : *(PLANT MATERIAL)* benih, entres, setek berakar umbi, akar rimpang, daun berakar,

Bahan Tanam Unggul Kakao

Kriteria keunggulan :

- Produktifitas tinggi
- Mutu hasil baik, sesuai keinginan konsumen (yaitu: berat biji > 1 gr, kandungan lemak > 55%, kandungan kulit ari < 12%)
- Tahan terhadap hama dan penyakit utama tanaman kakao

Alur Pemuliaan Tanaman Kakao

Koleksi plasma nutfah (koleksi lokal, introduksi, ekplorasi)

↓

Pengujian klon → → Klon unggul

↓

Persilangan antar klon (menghasilkan hibrida)

↓

Pengujian Hibrida F1 → → Hibrida F1 unggul

↓

Seleksi Individu

↓

Pohon induk terpilih

Klon : merupakan bahan tanam (vegetatif), hasil seleksi, dan harus diperbanyakan secara vegetatif

Hibrida F1 : merupakan bahan tanam (benih), hasil persilangan antara 2 klon tetua unggul, kerabat jauh, yang hibridanya telah terbukti dan teruji unggul

Klon Unggul KAKAO MULIA

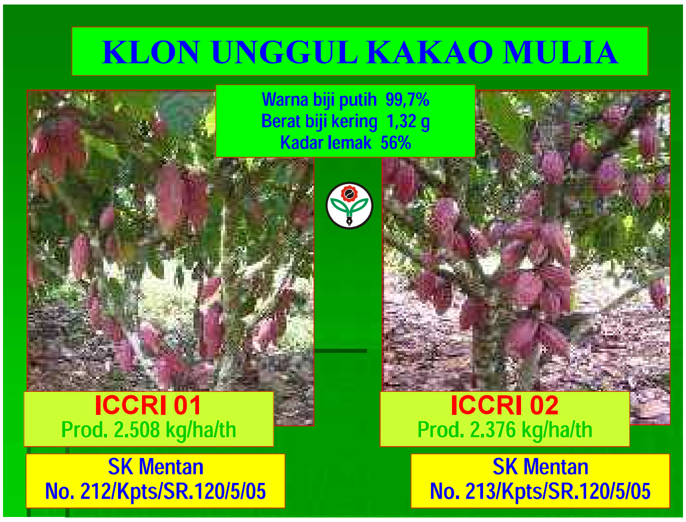
Klon DRC 16
1.735 kg/ha/th

SK Mentan
No.735/Kpts/TP.240/7/1997

Klon Unggul KAKAO LINDAK

Klon GC 7
2.035 kg/ha/th

SK Mentan
No. 736/Kpts/TP.240/7/1997


KLON UNGGUL KAKAO MULIA
Warna biji putih 99,7%
Berat biji kering 1,32 g
Kadar lemak 56%
ICCRI 01
Prod. 2.508 kg/ha/th
ICCRI 02
Prod. 2.376 kg/ha/th
SK Mentan
No. 212/Kpts/SR.120/5/05
SK Mentan
No. 213/Kpts/SR.120/5/05


ICCRI
KLON UNGGUL KAKAO LINDAK
ICCRI 03
Prod. 2.299 kg/ha/th
ICCRI 04
Prod. 2266 kg/ha/th
SK Mentan
No. 529/Kpts/SR.120/9/06
SK Mentan
No. 530/Kpts/SR.120/9/06


ICCRI
KLON UNGGUL KAKAO LINDAK
Klon Sulawesi 1
Klon Sulawesi 2
Klon Scavina 6
Potensi produksi tinggi, serta
cukup tahan terhadap VSD dan Busuk Buah


DR 2
DR 1
DRC 16
Sca 12
GC 7
TSH 858
ICS 60


Daun Tanaman Kakao


Tunas baru (Flush)
Warna Kemerahan
Warna Kekuningan

Bunga Kakao

Warna kekuningan

Warna kemerahan

PERBANYAKAN GENERATIF

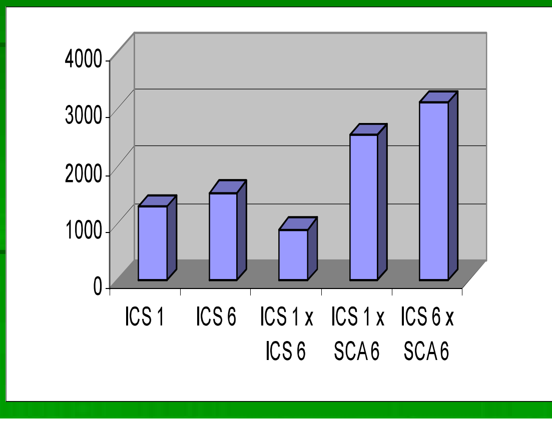
- Menggunakan bahan tanam benih / biji yang merupakan hasil perkawinan gamet betina (putik) dengan gamet jantan (serbuk sari)

- Tanaman kakao, merupakan tanaman tahunan, heterozygot, menyerbuk silang
- Jika bijinya ditanam, akan menghasilkan generasi segregasi yang sangat beragam, daya hasil dan mutu hasil yang tidak menentu
- Penggunaan benih sembarang akan menyebabkan ketidakpastian hasil / usaha, menyebabkan kerugian jangka panjang

Kakao Hibrida F1

- Persilangan dua klon tetua unggul yang kekerabatannya jauh
- menghasilkan tanaman hibrida dengan sifat hibrid vigor
- pertumbuhan tanaman jagur, cepat berbuah, berdaya hasil tinggi

HASIL PENGUJIAN SILANGAN

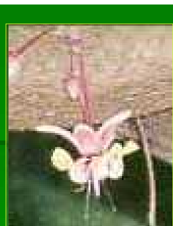


Hasil Persilangan untuk Kakao Hibrida F1

- Persilangan beberapa klon DR, ICS, TSH, GC yang *berbiji besar* dengan klon Sca yang *tahan hama penyakit*, telah terbukti dan teruji mempunyai daya hasil tinggi, mutu hasil baik, dan lebih tahan hama dan penyakit

Beberapa kakao hibrida F1 anjuran, prod. tinggi & tahan OPT, antara lain

ICS 60 x Sca 12, DR1 x Sca 12,
GC 7 x Sca 12, TSH 858 x Sca 12

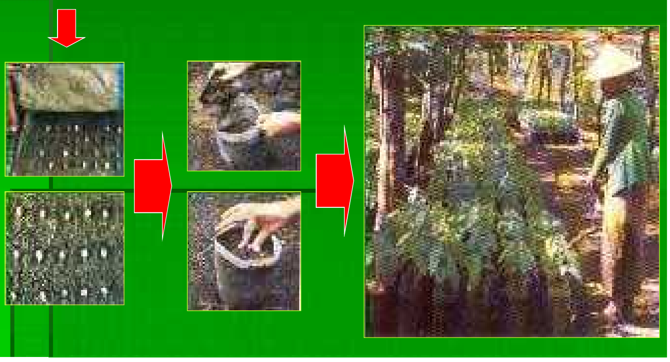


Bunga Kakao disilangkan

BENIH HIBRIDA F1

- Mrpk hasil persilangan 2 tetua unggul dan sdh teruji potensinya
- Benih → biji yg sdh dikupas kulit arinya

Persemaian dan Pembibitan Kakao



BIBIT KAKAO SIAP TANAM

Bibit kakao asal benih, tumbuh tegak dengan batang utama Ortotrof

Kakao Hibrida F1

PERBANYAKAN VEGETATIF

- Menggunakan bahan tanaman dari bagian vegetatif (akar, cabang, daun, atau bagian vegetatif lainnya)
- Dapat diperoleh tanaman baru yang mempunyai sifat genetik sama dengan induknya
- Dapat diperoleh pertanaman yang seragam, dengan daya hasil dan mutu hasil yang lebih terjamin

Klon Kakao
Bahan dalam bentuk Entres

Pertumbuhan dimorphisme

Cabang ortotrof

Cabang plagiotrof

Bahan entres / cabang

- Diambil dari tanaman klon unggul
- Pilih cabang yang tidak terlalu tua dan tidak terlalu muda
- Pilih cabang yang sehat

- Untuk digunakan atau dibawa di tempat yang jauh dari sumber entres, kesegaran entres harus tetap dijaga.
- Dapat ditutup ujung-ujungnya dengan parafin, dibungkus dengan pelepah pisang, koran basah, dan sebagainya

Perbanyakan vegetatif

Okulasi, Sambung pucuk, Setek, Cangkok, Kultur Jaringan

Perbanyakan vegetatif Secara Cangkok

Perbanyakan vegetatif

Okulasi, Sambung pucuk, Setek

Bahan untuk Okulasi, Sambung pucuk, Setek

Okulasi Pada Bibit Kakao

Perbanyakan vegetatif dengan cara Okulasi

Bibit Kakao Hasil Okulasi

Sambung Pucuk Pada Bibit Kakao

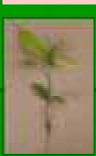
Perbanyakan Vegetatif dengan cara Sambung Pucuk

Bibit Kakao Hasil Sambung Pucuk

Perbanyakan Klon Unggul Kakao dengan teknik SE (Somatik Embriogenesis)

Perbanyakan di Laboratorium

Aklimatisasi Planet



Planet pasca aklimatisasi

Pengemasan planet pasca aklimatisasi

BIBIT UNGGUL KAKAO hasil perbanyakan SE

- Diperbanyakan dgn teknik SE di laboratorium
- Potensi genetik sesuai dengan klon asal
- Planlet pasca aklimatisasi dapat dikirim ke seluruh wilayah nusantara
- Bibit siap tanam, seperti tnm semaian, sifat klonal

Dengan penaung baik & penanaman yang tepat, tanaman kakao tumbuh subur

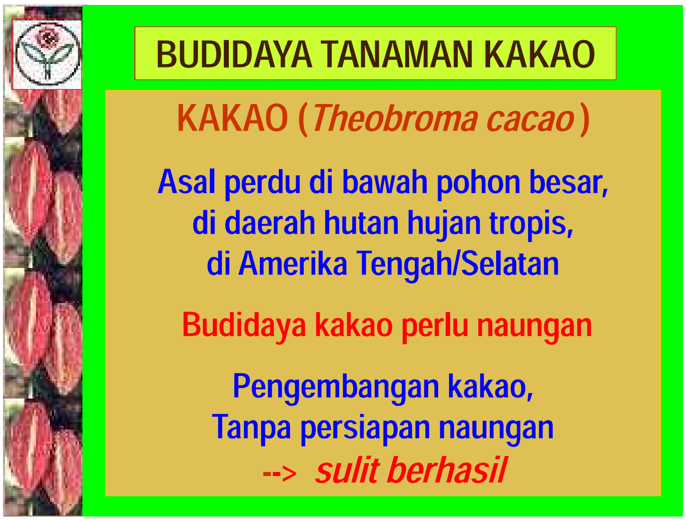
PENUTUP

- Bahan tanam merupakan modal dasar dan merupakan faktor penting dalam menentukan keberhasilan budidaya kakao
- Penggunaan bahan tanam unggul , harus diikuti dengan teknik perbanyakan & pembib itan yang benar, selanjutnya dlm pengelolaannya harus diikuti dengan penerapan budidaya yang tepat, sehingga potensi produksinya yang tinggi dapat dicapai

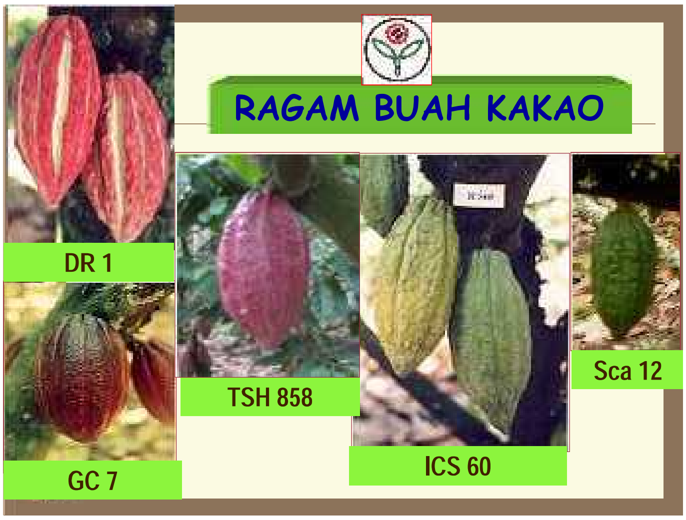
Penggunaan bahan tanam unggul dan diikuti dengan penerapan budidaya yang tepat, akan dicapai produksi yang tinggi

TERIMA KASIH

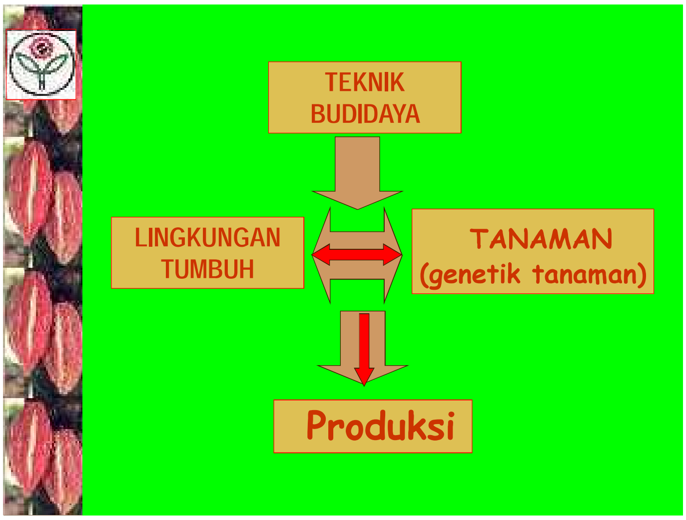

BUDIDAYA TANAMAN KAKAO
Hendro Winarno
PUSAT PENELITIAN KOPI DAN KAKAO INDONESIA
Jl. PB. Sudirman 90 Jember, Telp. (0331) 757130, 757132 Fax. (0331) 757131.
Email: iccri@iccri.net , Website : www.iccri.net


BUDIDAYA TANAMAN KAKAO
KAKAO (*Theobroma cacao*)
Asal perdu di bawah pohon besar,
di daerah hutan hujan tropis,
di Amerika Tengah/Selatan
Budidaya kakao perlu naungan
Pengembangan kakao,
Tanpa persiapan naungan
--> *sulit berhasil*


Berdasarkan Perdagangan
Kakao Mulia, Kakao Edel
(*Fine flavour cocoa*)
Biji daun kotil berwarna putih
dihasilkan dari tipe criollo atau trinitario
Kakao Lindak, Kakao Bulk
(*Bulk cocoa*)
Biji daun kotil berwarna ungu
dihasilkan dari tipe forastero atau trinitario


RAGAM BUAH KAKAO
DR 1
TSH 858
Sca 12
GC 7
ICS 60


Kakao Mulia
Biji putih
Kakao Lindak
Biji Ungu


TEKNIK BUDIDAYA
LINGKUNGAN TUMBUH
TANAMAN (genetik tanaman)
Produksi

Bahan Tanam Unggul

Kriteria Keunggulan :
- Produktifitas tinggi
- Mutu hasil baik, sesuai keinginan konsumen (yaitu: berat biji > 1 gr, kandungan lemak > 55%, kandungan kulit ari < 12%)
- Tahan terhadap hama dan penyakit utama tanaman kakao

KLON UNGGUL KAKAO LINDAK

ICCRI 03
Prod. 2.299 kg/ha/th
SK Mentan
No. 529/Kpts/SR.120/9/06

ICCRI 04
Prod. 2266 kg/ha/th
SK Mentan
No. 530/Kpts/SR.120/9/06

KLON UNGGUL KAKAO LINDAK

Klon Sulawesi 1

Klon Sulawesi 2

Klon Scavina 6

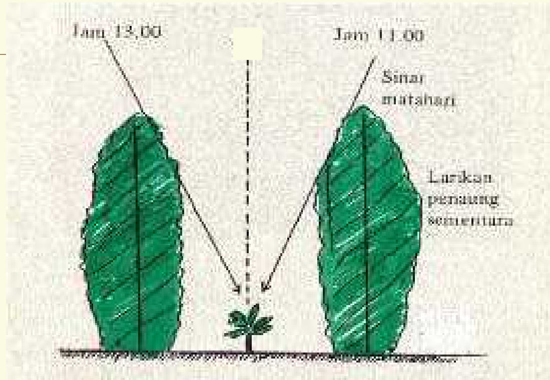
PERSIAPAN AWAL PENANAMAN KAKAO

- Evaluasi Kesesuaian lahan
- Persiapan lahan
- Persiapan Bibit dan Pembibitan
- Penanaman

PERSIAPAN LAHAN

Persiapan & Penanaman Penaung, 1 tahun sebelumnya

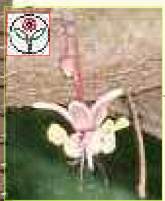
KONDISI PENAUNG YANG TELAH SIAP



Sinar matahari masuk antara jam 11.00 -13.00

BAHAN TANAM KAKAO

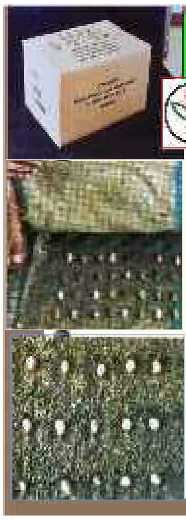
- **Generatif**
  Benih hibrida F1
- **Vegetatif**
  Entres klon unggul

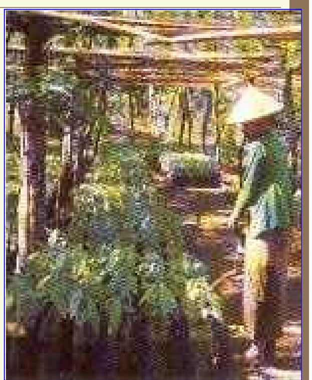


Bunga Kakao disilangkan

BENIH HIBRIDA F1
- Mrpk hasil persilangan 2 tetua unggul dan sdh teruji potensinya
- Benih → biji yg sdh dikupas kulit arinya

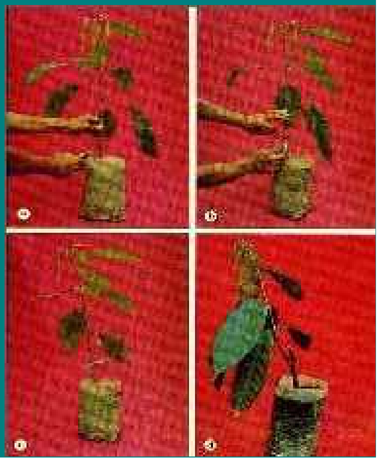
Persemaian dan Pembibitan Kakao



Klon Kakao
Bahan dalam bentuk Entres

Okulasi Pada Bibit Kakao



Sambung Pucuk Pada Bibit Kakao

Hasil Perbanyakan Bahan Tanam Klon Unggul Kakao dgn teknik SE (Somatik Embriogenesis)

ICCRI

Produksi di Laboratorium

Aklimatisasi Planet

Planet pasca aklimatisasi

Pengemasan planet pasca aklimatisasi

BIBIT UNGGUL KAKAO hasil perbanyakan SE

- Hasil perbanyakan dgn teknik SE di laboratorium
- Potensi genetik sesuai dengan klon asal
- Planlet pasca aklimatisasi dapat dikirim ke seluruh wilayah nusantara
- Bibit siap tanam seperti semaian, tetapi klonal
- Siap dimanfaatkan untuk Revitalisasi dan GERNAS kakao

BIBIT KAKAO SIAP TANAM

Bibit kakao asal benih

Bibit kakao klonal, hasil sambung pucuk

PENANAMAN KAKAO

Saat tanam tepat (awal hujan)

Naungan di lapangan telah siap

Bibit kakao siap ditanam
- tidak sedang bertunas / flush

Ditanam secara benar
- dijaga agar akar tidak rusak atau terganggu

PENGANGKUTAN BIBIT KAKAO

Bibit diangkut dengan dipikul hati-hati

CARA MENANAM BIBIT KAKAO

Bagian bawah polibag dipotong dengan pisau tajam

PENANAMAN BIBIT KAKAO

Bibit ditanam pada lubang tanam, Kemudian polibag ditarik

Dengan penaung baik, Tanaman kakao tumbuh baik

Tanpa / kurang Penaung, Penanaman kakao sulit berhasil

Di dekat Pisang (Penaung), tanaman kakao hidup tumbuh baik

PISANG SEBAGAI PENAUNG KAKAO

Penaung Pisang, dan pre cropping dengan kacang tanah

Tanaman Penaung Glirisidae,
Diatur, pada akhir dan awal musim hujan pangkas 50%

Kelapa sebagai penanung Kakao

Jarak kakao dengan kelapa, ditata minimal 3 m

Tempat yang terbuka, Perlu tambahan Penaung Pisang, Moghania macrophylla, atau lainnya

Tanaman Jati / Kayu-kayuan,
sebagai Tanaman Tepi, Pematah Angin, dan Investasi

Pengelolaan Tanaman Kakao

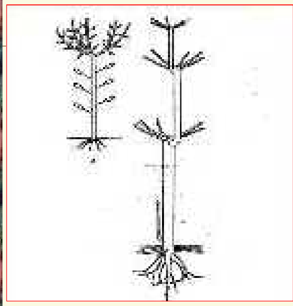
Pertumbuhan dimorphisme (2 macam cabang)
- Cabang ortotrop (tegak, duduk daun 3/8)
- Cabang Plagiotrop (Agak ke samping, duduk daun 1/2)

Pembungaan dan pembuahan
- Bersifat Cauliflorous (menempel pada batang/cabang)
- Berbungan/berbuah sepanjang tahun (tidak mengenal musim)

Perlu diatur melalui P A N G K A S A N
- Percabangan kuat dan seimbang
- Perdaunan merata
- Pertumbuhan dan produksi tinggi

Bibit tanaman kakao yang telah ditanam dan tumbuh subur, perlu dikelola dengan baik sehingga dapat memberikan produksi yang tinggi

Pertumbuhan Tanaman Kakao



Tanaman kakao tumbuh terus menerus
+ Dari cab Ortotrof, ... tumbuh ortotrof
+ Dari cab Plagiotrop,... tumbuh plagiotrof
Tidak dipangkas → Rimbun

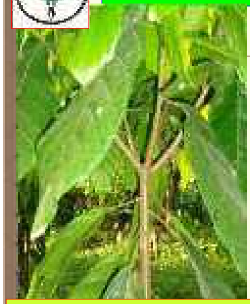
WIWILAN TUNAS AIR,
- segera
- tanpa alat
- dgn tangan / wiwil

Tua, Terlambat,
harus pakai alat,
Tambah banyak tunas

Tunas air, harus segera diwiwil

Bibit kakao asal benih

Pangkasan Bentuk



Jorget / Perempatan dgn cabang primer 4-6 cang
Perlu dikurangi menjadi 3 cabang

- Ditinggalkan 3 cabang, yang sehat, kuat, dan sebaran merata
- 60 cm dari jorget bersih

Dengan percabangan yang kuat, seimbang, serta dengan daun sebarannya merata
Akan diperoleh buah kakao yang optimal

Pangkasan Pemeliharaan/Produksi

Cabang/Ranting yang sakit, kering, tumbuh ke bawah, masuk daerah tetangga, saling menutupi *PERLU DIPANGKAS*

Pangkasan Pucuk Kakao

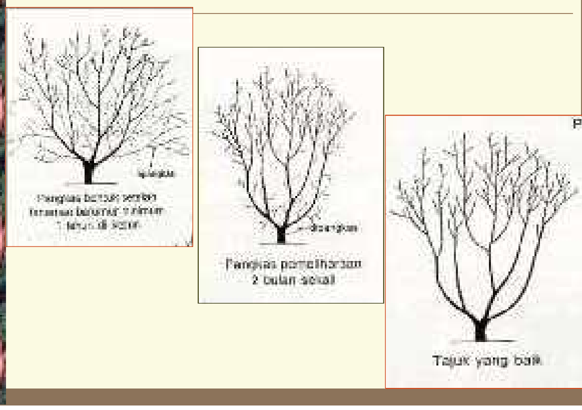
Pucuk yang meninggi, perlu dipangkas
Tinggi tanaman dipertahankan 3-4 m

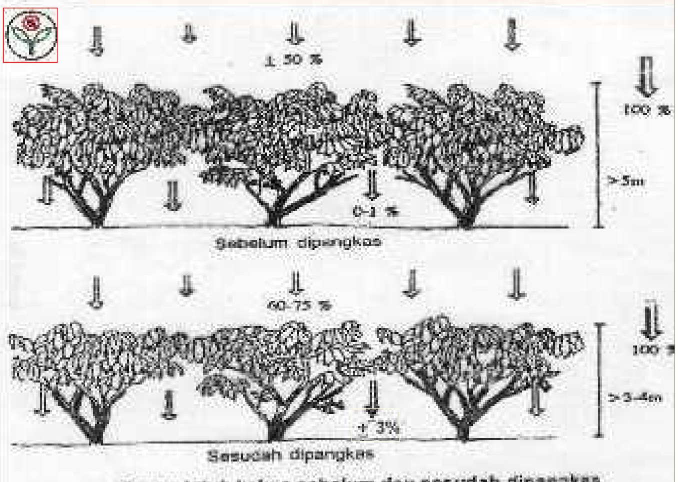
Bibit kakao klonal,
hasil pembiakan vegetatif plagiotrof

Bibit klonal Plagiotrof,
dari bawah sudah bercabang seperti kipas
Perlu diatur dan dipangkas,
Sehingga seperti mempunyai jorget

Buah pada batang / cabang
tempat bunga dan buah
Perlu terus disediakan,
dijaga , dan dipelihara

Pangkasan Tanaman Kakao



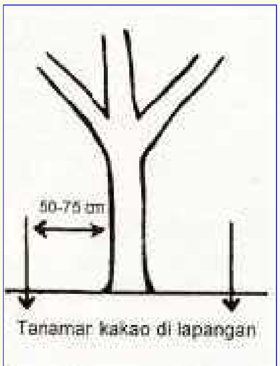


Bagan tajuk kakao sebelum dan sesudah dipangkas

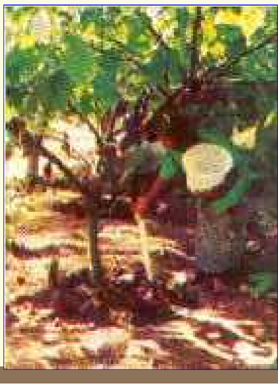
Alat Pangkas Tanaman Kakao

Pemupukan Tanaman Kakao

4 Tepat (Dosis, Jenis, Waktu, dan Cara)



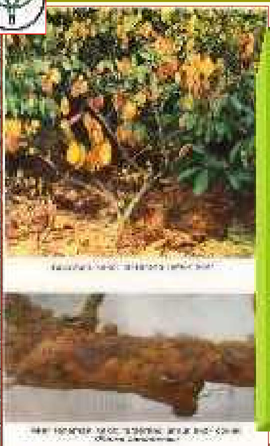
Tanaman kakao di lapangan



Dosis Pupuk Tentatif untuk Kakao

Umur/Fase	Satuan	Urea	TSP	KCl	Kis
Bibit	g/bibit	5	5	4	4
0-1 th	g/ph/th	25	25	20	20
1-2 th	id	45	45	35	40
2-3 th	id	90	90	70	60
3-4 th	id	180	180	135	75
>4 th	id	220	180	170	120

PENYAKIT JAMUR AKAR COKLAT



Pengendalian

- Sanitasi, dongkel tanaman sakit, bersihkan (bakar). Bekas lubang beri belerang 600 gram/lubang
- Buat parit isolasi, dalam 80 cm, keliling 1 baris di luar tanaman yang sakit
- Pada piringan tanaman di sekeliling yang sakit, taburi dgn 300 gram kapur, siram dengan larutan urea 60 gram/5 liter

PENYAKIT PEMBULUH KAYU, VSD

Pengendalian

- Sanitasi, pangkas ranting sakit, sampai jaringan coklat +30 cm
- Lindungi flush/ tunas baru dgn fungisida
- Gunakan klon / bahan tanam yang tahan

PENYAKIT BUSUK BUAH KAKAO (*Phytophthora palmivora*)

Pengendalian

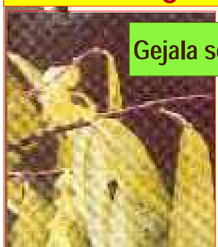
- Sanitasi, ambil buah busuk, benam dalam tanah
- Kurangi kelembaban Pangkas kakao dan naungan
- Lindungi dgn fungisida Cu
- Gunakan klon/bahan tanam yang tahan

HAMA ULAT KILAN

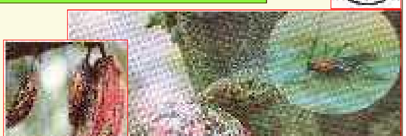
Pengendalian

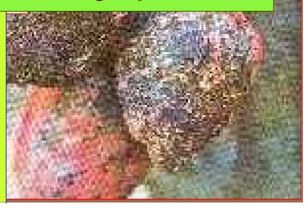
- Ranting / daun yang terserang ulat → potong, bunuh, benam
- Semprot dengan insektisida seperti Decis, Matador, dsb
- Biji menggunakan nabati ekstrak Mimba 5-20%

Hama Penghisap Buah Kakao (*Helopeltis sp*)



Gejala serangan pada pucuk/tunas baru



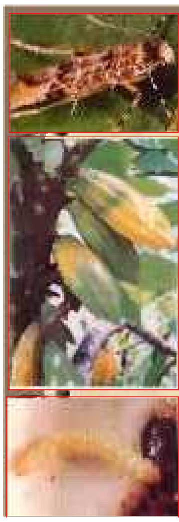


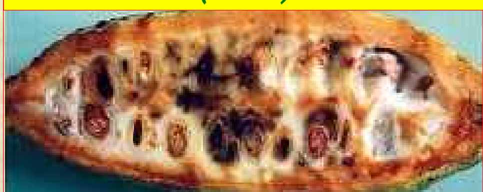
Gejala serangan pada buah

Pengendalian

- Semprot dengan insektisida
- Gunakan teknik SPD
  1 tanaman + tan sekelilingnya >15% semprot secara blangket
- Hayati: *Semut hitam, Beaveria*

HAMA *PENGGEREK BUAH KAKAO (PBK)*



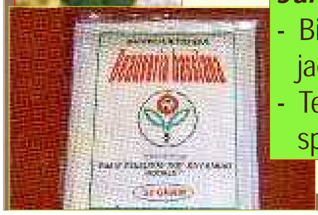


Pengendalian

- Sarungi buah ukurang < 8 cm
- Panen sering, tiap ≤ 7 hari, kulit buah dan plasenta: benam / cacah
- Sanitasi buah terserang: benam / cacah
- Hayati: *Semut hitam, Beaveria*
- Pangkas pucuk, shg tinggi tanaman 3-4 m

PENGENDALIAN HAYATI

SEMUT HITAM
- Perlu Sarang
  (daun kakao dalam kantong plastik)
- Perlu kutu putih



Jamur Beauveria bassiana
- Bisa dibuat dgn media beras jagung
- Tersedia dalam bentuk tepung spora

Perbanyakan dengan cara SAMBUNG SAMPING

Rehabilitasi Tanaman Kakao Hasil Sambung Samping

Melalui Penerapan Teknik Budidaya yang benar, kita raih poduksi kakao yang tinggi

Panenan Buah Kakao

- Panen buah yang masak
- Menggunakan alat yang tajam
- Tidak merusak bantalan bunga / buah

TERIMA KASIH

COLOPHON

This document was typeset using the typographical look-and-feel `classicthesis` developed by André Miede. The style was inspired by Robert Bringhurst's seminal book on typography "*The Elements of Typographic Style*". `classicthesis` is available for both LaTeX and LyX:

http://code.google.com/p/classicthesis/

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