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Reducing Agricultural Income Vulnerabilities through Agroforestry Training: Evidence from a Randomized Field Experiment in Indonesia

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Abstract

Although agroforestry is recognized as a means to stabilize farm income, little attention has been given to differentiating among farmers with different income levels, varying capacities to diversify their crops, and the economic outcomes of adoption. This paper examines agricultural training effects in promoting agroforestry by distinguishing between the poor and non-poor farmers to evaluate the relevance of agroforestry systems to the poor, the extent of adoption, and the economic consequences. We found that although training has generally increased participants' knowledge, it has positive effects in increasing crop diversity only for the poor participants. We also detected the presence of spillovers from the participants to non-participants, which may increase crop diversity among non-participants and consequently reduce program impacts. When income heterogeneity is considered, we found that the poor training participants benefited more from increasing incomes and expanding their social network relative to the non-poor. Agroforestry adoption is also found to help reduce income volatility.

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Keywords: agrofrestry; agricultural training; impact evaluation; social network, information diffusion

1. INTRODUCTION

In Indonesia, most economically marginalized people live in rural area and depend on agriculture and forestry for their livelihood. According to the World Development Report, in 2008, 54% of the Indonesian population was living below the poverty line[c], and the majority of whom live in rural areas (Bank 2008). Despite its declining share in GDP, agriculture still provides income for almost half of Indonesians (in 2012, 49 million persons or 41% of the total labor force[d]). Programs aimed at increasing agricultural productivity play important roles in reducing poverty because higher productivity from improved practices would translate into higher output market integration, which would lead to improved incomes (Asfaw et al. 2011).

Agroforestry may become one option to tackle rural poverty and environmental problems simultaneously because it can provide multiple economic and environmental benefits to farmers (de Foresta, Michon, and Kusworo 2000). A widely-accepted definition of agroforestry was formulated by Lundgren and Raintree (1983): "Agroforestry is a collective name for land-use systems in which woody perennials (trees, shrubs, etc.) are grown in association with herbaceous plants (crops, pastures) or livestock, in a spatial arrangement, a rotation, or both; there are usually both ecological and economic interactions between the trees and other components of the system." Some forms of agroforestry techniques require low external inputs and efficient integration of trees, making them good candidate for achieving both sustainable livelihood and ecological objectives (Koohafkan, Altieri, and Gimenez 2012). The simplest and most traditional agroforestry practices are crop diversification or inter-cropping (called *tumpangsari* in Indonesian).

Development interventions aimed at promoting agroforestry have ranged from participatory programs incorporating both technical training and knowledge sharing to improve ecological and

[c] US$ 2 a day serving as the World Bank's poverty line measure

[d] http://www.indonesia-investments.com/culture/economy/general-economic-outline/agriculture/item378 accessed 2018/09/25

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, Lee, and Schelhas 1996). In Indonesia, training programs aimed at agroforestry practices were both externally and government-funded, and have been tailored to the needs of local farmers, such as integrating timber in Yogyakarta (Rohadi, Herawati, and Lastini 2015), fruit crops in Aceh (Roshetko et al. 2008), and rubber in Kalimantan and Sumatra (Budiman and PENOT 1997).

Most agroforestry program in the country prioritized land rehabilitation and are largely focused in generating long-term economic gains from one specific crop. Little is known about whether and how poor farmers behave differently from the non-poor in adopting agroforestry practices. Achieving fully what the agroforestry system offers requires a fundamental understanding of how and why farmers make long-term land-use decisions. This paper aims to complement the understanding of such topics, particularly by explaining linkages among the variables of economic, social, and ecological aspects of agroforestry using a randomized-controlled trial (RCT) over a shorter time-period.

We designed the study to estimate not only the impacts of the training program on the ultimate outcome of farmers' well-being, but also to examine the impacts on other intermediating outcomes such as adoption of new types of crops as well as changes in farmers' rural institutions. For this purpose, we provided agricultural training to half of our sample of coffee and/or cocoa farmers in Lampung region. We invited them to participate randomly, through lottery draws, and we evaluated the training impact over two consecutive years after the training ended. The training focused on basic cultivation that emphasized the importance of diversity in cultivated crops apart from the main cash crops. The program evaluation period spanned a two-year period to ensure we captured the program's short- and mid-term impacts.

We selected technical training as the form of intervention because even through agroforestry is an old practice that has been traditionally adopted in many parts of Indonesia, the level of adoption has generally lagged behind technological advances attained in such technologies, thereby reducing their potential impact (Mercer 2004; Garrity 2012). Farmers are still facing information constraints caused by the knowledge-intensive nature of agroforestry systems, particularly regarding access to public or private extension services and knowledge of 'best practices,' which extend beyond simple awareness creation.

Our study did not find statistically significant effects from training on agroforestry adoption in general despite the increased knowledge regarding the benefits of such practices. However, when income heterogeneity is taken into account, we found that training's effects differed between the poor and non-poor. The non-poor seemed to reduce the number of crops by category due to the crop specialization strategy. The poor however, tended to increase the number of crops by diversity resulting in the increase in their aggregate income relative to the non-poor but do not expand to other crop category. We also found that the reported benefits as perceived by the farmers in the survey sample varied depending on their income level. General results suggest that they conserved soil and water and have benefited from obtaining a source of fuel-wood. Meanwhile, the poor reported increased extraction of produce for medicinal purposes, which suggest that they may have procured some medicinal herbs from their farmland due to increased crop diversity. We also find the presence of spillovers between participants and non-participants, which partly explains the lack of a general impact from training because non-participants increased crop indices too. Furthermore, although training had no effects in terms of expanding general participants' social networks, poor participants seemed to increase both depth and size of their networks upon returning from the program relative to the non-poor, which is likely to influence their increased crop indices by diversity. Finally, we discovered that agroforestry in the medium-term is negatively correlated with farm income variation. The agricultural production and farm income report showed that in general, participants seemed to adopt spice crops in place of legumes because they earned increased income from that commodity. However, for the non-poor, their income from spice commodities cannot offset the loss of income incurred by abandoning the legume crops in the first few years, making their income seemingly reduced compared to the poor, who benefited from the constant income from legume crops.

The paper proceeds as follows: Section 2 provides the hypothesis; Section 3 elaborates on the study area and situation in Indonesia; Section 4 describes the methodology and social interventions provided; Section 5 builds on the empirical strategy; Section 6 provides the estimation results, and finally Section 7 concludes with a discussion.

2. CONCEPTUAL FRAMEWORK

We aim to examine effects of training upon agroforestry adoption, perceived benefits, and eventually farm income stability. To serve these purposes, we present several hypotheses:

Hypothesis 1: Training participants will have a higher plant diversification index relative to non-participants.

Regardless how efficient and productive they may be, agroforestry systems can only contribute to both economic and environmental sustainability if they are adopted and maintained. Risk and uncertainty have been recognized as important factors in reducing adoption of agricultural innovations (Feder and Umali 1993). However, a meta-analysis study by Pattanayak et al. (2003) found that agricultural extension and training offered by governmental advisory services to facilitate transmission of agricultural information to farmers in rural areas are able to mitigate risk and uncertainty to some extent. Their study also highlighted that tenure, experience, extension, and training are far more likely to be significant predictors of adoption of agroforestry than organization memberships.

Agroforestry is a long-term process whose benefits can take a long time to accrue. To sustain the required practices, it is important to include shorter term benefits to farmers in the initial stage of adoption to help prevent farmers from becoming discouraged. Agricultural training that emphasizes agroforestry may be an excellent opportunity to provide short-term benefits arising from improving basic agricultural knowledge while also offering a long-term extension for agroforestry practices (Thorlakson and Neufeldt 2012). Given the complex and continually evolving knowledge involved with agroforestry, the current extension system might not be sufficient to overcome farmers' lack of access to information, especially in Indonesia where the number agricultural extension service officers in the rural area are limited.[e]

If farmers can be educated with the most recent knowledge regarding the potential of their crop mix to enhance their well-being, they may change their attitudes regarding risk and uncertainty and therefore make more concentrated efforts toward farm management and tree planting.

Previous studies on agroforestry training have mostly dealt with the environmental impacts. In terms of economic well-being, training has been reported to increase production of fruit crops (Roshetko et al. 2008; Asaah et al. 2011), timber (Rohadi, Herawati, and Lastini 2015), and rubber (Budiman and PENOT 1997) among other. However, Blair et al. (2013) did not find significant effects from training due to capital constraints and risks associated with agroforestry practices.

Hypothesis 2: Training participants will have better awareness of perceived agroforestry benefits relative to non-participants.

Pastur et al. (2012) posits that farmers who do acknowledge the merits of agroforestry will incorporate certain agroforestry techniques into their farming practices if they can afford to do so. Economically, agroforestry can diversify farm operations (Caviglia‐Harris and Sills 2005) and livelihood strategies (Cramb and Culasero 2003), which can reduce risk and increase resilience, especially for smallholder farmers (Lin 2011). In the longer term, agroforestry can reduce poverty by enhancing farm incomes (Leakey and Tchoundjeu 2001), providing provisions for fodder, fuel-wood, and medicinal needs (Akinnifesi et al. 2008), generating employment (Asaah et al. 2011), ensuring

[e] Starting in 7th January 2015, following the Memorandum of Understanding (MoU) between Ministry of Agriculture and Chief of Staff of the Army, the Indonesian Army's territorial function includes helping to carry out tasks of agricultural extension services in rural areas, supporting the government's food self-sufficiency program. Among their tasks are to help with maintaining facilities such as renovating irrigation canals and the distribution of seeds and fertilizer. The implementation of army's territorial function was done by KODIM (Komando Daerah Militer) at the regency level, KORAMIL (Komando Rayon Militer) at the sub-district level, and Babinsa (Bintara Pembina Desa) at the village level (see Nabawi (2016)).

food security (Garrity et al. 2010), and enhancing livelihood opportunities (Leakey et al. 2005). Agroforestry can bring not only economic but also environmental benefits, including soil and water conservation (Bekele-Tesemma 1997), increased soil fertility (Young 1989), and improved or maintained surroundings (Regmi 2003).

The provided training aimed to enhance farmers' awareness of the multiple benefits of agroforestry. Heightened awareness would then influence farmers' decision to integrate more crops and trees on their farmland. More knowledge of agroforestry would also help farmers decide which tree species to plant and how to maximize the farm and ecosystem services, as well as benefits derived from them.

Hypothesis 3: Training participants have higher propensity to diffuse knowledge regarding agroforestry to non-participants.

All training participants, despite income differences, are expected to increase their communication intensity with their agricultural advice network upon returning from the training. Because information is embedded in social interactions (Granovetter 1973), knowledge gained from the training is also more likely to be transferred from training participants to non-participants. Therefore, considering that agroforestry's benefits are communicated during the training course, farmers may be able to understand its merits, thus accelerating the diffusion of agroforestry practices in their community. A recent study by Martini, Roshetko, and Paramita (2016) showed that fellow farmers significantly help disseminate information related to agroforestry in Sulawesi.

Hypothesis 4: Training participants will expand the depth and size of their social network, which influences adoption.

Farmers who have larger networks are more likely to make changes in their practice. Rogers (2010) examined studies on agricultural and non-agricultural settings in developed and developing countries and concluded that early adopters have greater social participation. Interactions with others, including neighbors, experts, and families, can lead to changes in 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, but they also have the opportunity to test and change values and attitudes.

Agricultural extension services have a history of being relatively expensive and not always effective. In this respect, informal social networks can be very beneficial in helping increase productivity. Farmers' decisions to adopt a new crop is influenced by friends and family (Bandiera and Rasul, 2006), and they learn through imitating others (Conley and Udry, 2001) as well as from more experienced neighbors (Foster and Rosenzweig, 1995). Farmers who are more active in their network have also been found to be better able to capture agricultural information during learning activities (Pratiwi and Suzuki 2017). Network mechanisms among the poor and non-poor tend to differ, with social status within villages affecting outcomes of dissemination methods. The poor will possibly solicit more information from peers, whereas the non-poor may primarily obtain knowledge from extension agents. Recently, Lubell and Fulton (2008) also found that social-network-based programs have increased productivity; the poorest performing farmers are the ones who is the most benefited from such programs (Vasilaky 2013).

Hypothesis 5: In the shorter-to-medium timeline, agroforestry adoption will have indirect impacts in reducing income vulnerabilities, especially for poor farmers.

Smallholders farmers are the most vulnerable to the risk of crop failure. Given their limited resources, they have no means to diversify their agricultural livelihood strategies. However, with the right combination of perennial crops aside from the main cash crops, poor farmers could undertake cultivation of complementary crops, which are different in nature from their main cash crops; and this could help them diversify their production. In small-sized garden plots, agroforestry can provide benefits arising from a diverse range of tree and annual species. By combining hardwood species that provide long-term returns (Thorrold et al. 1997) with perennial crop species that provide short-term income, agroforestry systems are expected to improve farmers' livelihood. Diversified production also helps smallholders protect themselves from crop failures. In studies by Omamo (1998) and Gaiha and

Imai* (2004), agroforestry was found to reduce income vulnerabilities. It may also lead to increase economic resilience and reduce risk (Lin 2011).

3. STUDY SITE

3. 1. Study Context

Lampung Province, the study field site, is one of top producers of Robusta coffee and cocoa beans. Coffee and cocoa have been two of Indonesia's most important export commodities (Kaplinsky 2004), with the country ranking as the world's fourth biggest coffee producer[f] and the third largest cocoa exporter.[g] Indonesian smallholders contribute most of the national production of these two commodities, overshadowing large state plantations and private estates (Dietsch et al. 2004). Coffee- and cocoa-based agroforestry systems are popular with farmers because these crops are highly valued commodities and can create jobs (Budidarsono and Wijaya 2004).

Until the late 1960s, Lampung was covered with rainforest. Then settlers arrived and opened some land for cassava cultivation and establishment of tree gardens. In the 1980s, the government carried out major land clearances s as part of its transmigration program, primarily relocating farmers from Java island. Smallholder farmers in Lampung currently cultivate a variety of tree gardens, including monocultural systems, multispecies gardens, and agroforests, which are tree garden systems that resemble natural forests (Roshetko and Purnomosidhi 2008). Nevertheless, the country is facing challenges in boosting the economic contribution of the region's two crops. Even though the country's geography and micro-climates are all well-suited for the production of coffee and cocoa, environmental degradation due to harmful agricultural practices is apparent. The majority of output is produced by smallholders who lack the financial means to optimize their production capacity, resulting in declining production due to aging trees, diseases, and floods.

Lampung is subdivided into 12 regencies and two autonomous cities. Major crops include Robusta

[f] Statistics compiled by International Coffee Organization http://www.ico.org/prices/po-production.pdf retrieved May 23, 2015
[g] Statistics compiled by UN Food and Agriculture Organization http://faostat3.fao.org/home/E retrieved May 23, 2015

coffee beans, cocoa beans, coconuts, and cloves. This study's survey was administered in Tanggamus district because that area is recognized as the highest coffee and cocoa producing district in Lampung, in addition to sufficient accessibility and the existence of professional contacts. Coffee-producing areas span around 43,941 hectares with 30,143 tons of product annually[h].

3. 2. Agriculture Characteristics and Techniques

Farm management in Tanggamus varies from traditional shaded coffee gardens to complex agroforestry system that combines many species of trees with various types of agricultural crops. Traditional agroforestry practices, such as the planting fruit trees in home gardens and close to family dwellings, are prevalent among smallholder farmers. In the study area, annual crop plants such as rice, cucumber, and tomato; perennial fruits such as banana, papaya, avocado, durian, and snake fruit (*Salak*); perennial industrial crops such as cocoa, coffee, coconut, rubber, and oil-palm; perennial herbs such as ginger, nutmeg, pepper, long pepper, and chili; perennial vegetables such as breadfruit, eggplant, and 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.

3. 3. Agricultural Extension System

Before the decentralization, two major agricultural extension programs were implemented in Indonesia, namely the Training and Visit (T&V) Extension Program from the mid-1960s until the 1980s, and the Farmer Field School (FFS) Program, during the 1990s (Resosudarmo and Yamazaki 2011). In general, information was disseminated through extension visits to regular farmer group meetings. A farmer group consists of farmers cultivating the same commodity of interest and comprises 20 to 30 people living in the same neighborhood. One or two extension workers were assigned to each group to monitor the farmers' progress and advances at least once a month through monthly group meetings.

After decentralization, as a means of increasing regional government autonomy, the central

[h] http://tanggamuskab.bps.go.id/ accessed 2015/09/15

government transferred the responsibility and funding to the district level (Herianto et al. 2010). Indonesia's official extension system is now carried out through farmer groups, following Law 16/2006 on Extension System for Agricultural, Fishery and Forestry (Neilson 2008). The law recognizes the roles of multi-provider actors including government and private-sector extension workers as well as self-supporting extension volunteers. Some challenges are found in the implementation throughout the country; for instance, much district level funding is allocated to routine programs rather than agricultural development and related extension activities (World Bank 2001). As a result, extension agents are uncertain about their roles, poorly paid, and get little support for their activities. There are limited numbers of extension agents with limited technical capacity, including limited training experience and lack of access to capacity-building opportunities (Martini, Roshetko, and Paramita 2016).

According to interviews with Tanggamus district Crop-Estate official in 2012–2014, private sectors have increasingly played important roles in delivering extension services for coffee and cocoa farmers in Lampung with a focus on promoting commercial crops. The exporters association, for instance has provided farmers with high-quality seedlings and education for a Rainforest Alliance coffee certification. For specialized training and education, farmers need to send a proposal to ask for training when they feel the need. Several multi-national companies that procure beans from the area have consistently provided high-quality seedlings as well as marketing and, periodically, information and education to farmers through the government's extension official, who also served as the company's agents on a periodic basis.

4. DATA

4. 1. Description of Household Survey

The study was carried out between September 2012 and September 2014, and we have baseline data for 2012 and post-program data for 2013 and 2014. Our sampling is based on a stratified sampling approach. We selected Tanggamus district due to its appropriateness as the top producing area of coffee and cocoa in Lampung province, ease of access, and professional contacts within the district government. We then selected two top coffee and cocoa producing sub-districts in the area, namely Sumberejo and Pulau Panggung. These two sub-districts provided 36 active farmer groups in the area, from which we randomly selected 16 farmer groups as our main object of the survey. Then, out of these 16 farmer groups, we targeted all farmers as potential survey participants. In 2012, there were 360 farmers in these groups, and we managed to interview 312 of them (87%). The remaining 48 farmers were not available for interview due to age, health conditions, or simply refusal to be surveyed. Because we randomly chose farmer groups, we do not have farmers who do not belong to farmer groups in our sample. Thus, we need to interpret the results of our analyses as representing farmers who belong to farmer groups. Face-to-face interviews were carried out with self-identified household heads, and we particularly asked about their socio-economic characteristics and agricultural activities, as well as agricultural advice network.

4. 2. Social Intervention: Agricultural Training

As knowledge variations exist among extension workers, and in some isolated areas, extension coverage is not extensive, farmers may find that the current extension system is lacking and ineffective. Critics of group-based approaches have pointed out that the system works better for the non-poor than the poor due to its tendency to exclude farmers of lower social status who are less likely to participate in or dominate within groups (Place, Adato, and Hebinck 2007). A recent survey conducted by Martini, Roshetko, and Paramita (2016) recognized that the most appropriate extension approach for farmers is introducing more practical technologies via establishing demonstration trials as well as via field visit to successful farmers.

Responding to this situation, we decided to provide participants with agricultural training from experts at the national research institute; this training is usually provided to train extension officials. Our purpose is to examine whether providing training directly to farmers, which incorporated features such as field visits to pilot farms and successful farmers, has any impact upon farmers' attitudes and perceptions toward diversification.

(Table 1 here)

In February 2013, we invited randomly selected 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 in coffee and cocoa cultivation, respectively, and the last day would be spent on a field trip to a coffee and cocoa pilot farm. Extension officials helped to carry out the randomization process during farmer groups' monthly meetings in February 2013, whereby each farmer picked the lottery to obtain eligibility for the training program and their location straightaway. This way, the poor would be as likely to be selected as non-poor farmers. After randomization, no significant differences were found between the control group and treatment group in terms of basic characteristics such as education, income, and community characteristics (refer to Table 1). However, in terms of income status, non-poor farmers in the control group possess larger farmland by on average 0.29 hectares relative to the treatment group, but those in the treatment group have more extensive advice networks from outside their farmer group communities than the control group.

To examine heterogeneous effects of training depending on training location, we administered the training in three different locations: (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 the more developed Java Island. Of the total 156 farmers, 52 farmers were randomly assigned to each of the three training locations. The program was implemented with coordination of four district governments, and participants in the intra-island and inter-island training were provided with accommodation, food, and travel insurance during the trip and training.

(Table 2 here)

Table 2 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. Considering the randomization results in Table 2, more non-poor farmers were selected than poor farmers; however, in terms of participation, a greater percentage of non-poor farmers did not participate (21/82 = 26%) than poor farmers (15/74 = 20%)[i].

Two professional trainers from the Indonesian Coffee and Cocoa Research Institute (ICCRI) were invited to provide lectures during the first two days. The trainers and training program materials were identical at each location and it was ensured that all training locations offered a similar environment. The in-class training materials for coffee and cocoa on the first and second days consisted of basic cultivation training[j] such as (1) information on shade trees and crop diversification; (2) information on fertilizer, including ways to procure organic fertilizers from livestock; and (3) ways to select high-yield varieties and crop and pest management. The third day primarily consisted of a pilot farm visit where trainers gave practical information on how to maintain a plantation using the situation and conditions in the pilot farm as an example. On the last day, we also organized a forum to enable participating farmers to meet successful farmers in the area to exchange information.

Post-evaluation surveys were conducted twice, in September 2013 and 2014, resulting in a three-year panel dataset. Because of random assignment of farmers into treatment and control groups, we can assume that any significant differences observed between the two groups at the end of the treatment period could be attributed to the actual program or intervention, allowing the calculation of unbiased estimation of the counterfactual effect. During the post-evaluation survey, farmers reported a decline in production due to a crop disease that caused the buds of cocoa and pepper to rot prematurely.[k] Climate condition, such as high rain intensity and strong winds, became the major

[i] This fact may suggest that some differential selection into the program between non-poor and poor farmers still remains even though we tried our best effort to minimize any bias.

[j] The training was delivered in Bahasa by two professional trainers who were ethnically Javanese. However, majority of farmers in Lampung listed Bahasa Indonesia as their first language, and the trainers encouraged the farmers to ask questions during training if they did not understand. Moreover, the training was conducted in the most “casual” version of Bahasa, which is not very “formal” or “academic”.

[k] See for instance http://kpbptpn.co.id/news-8250-0-petani-kakao-di-tanggamus-resah-merebaknya-penyakit-buah-busuk.html last accessed 24/12/2016

factor in the epidemiology. At the same time, the high rain intensity had caused floods in some areas, resulting in crop failure.[l]

5. EMPIRICAL STRATEGY

5. 1. Dependent Variables

(Figure 1 here)

Our main objective is to examine the effects of training upon the differing agroforestry adoption patterns between low- and high-income farmers. As shown in Figure 1, the baseline survey found that agricultural income is skewed toward lower incomes. Farmers' median annual farm income[m] is around Rp. 12,800,000 (or less than US$ 1,000); hence, we regard poor farmers as those whose income falls below the median farm income. We examine whether training has had any impact upon the following variables.

1. **Agroforestry index**

   We constructed two different agroforestry indices, the first being formulated according to crop category and the second according to crop type. We classified the crop list into several categories encompassing cereal, leguminous, industrial, spices, vegetable, fruit crops, and hardwood, which were called crop categories. For instance, if a farmer cultivated coffee and pepper, that farmer would be considered as having crops in two categories because coffee is classified as an industrial crop and pepper as a spice crop. Crop diversity, on the other hand, considers any type of crop. If a farmer cultivates coffee and cocoa in the farmland, that farmer is considered having a crop diversity of two, but only one crop category because both coffee and cocoa are classified as industrial crops. The index is constructed as the total number of commodities that farmers cultivate on their farmland.

2. **Perceived benefits of agroforestry**

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[l] See http://lampungnewspaper.com/v2/headlines/2824-banjir-masih-mengancam-warga-semaka and http://www.sinarharapan.co/news/read/31513/banjir-pasokan-pangan-lampung-terganggu last accessed 24/12/2016

[m] Farm income is defined as total revenue from agricultural activities including provision from honey and dairy but excluding non-farm income.

In the questionnaire, we asked 10 statements on agroforestry benefits perception[n], but we only reported five in this paper because the rest were not found to be significant. Those benefits we reported here in latter part are the reduced chances of complete crop failures, maintained/improved surrounding condition, extraction of trees for medicinal purposes, extraction of trees for fuelwood, and conserved soil and water. Those benefits we decided to drop due to the lack of significance are extraction of trees for fodder, increased variety of food income, increased provision for shade trees, increased soil fertility, and increased farm income. We asked farmers about their perception of agroforestry benefits[o] if farmers cultivate more than one crop category or diversity on the farmland, that is, when they actually have practiced agroforestry. We asked the question as a statement, i.e., whether they think they are getting the benefit of agroforestry when they have more than one crop. The answer is coded as Yes, No, or Don't Know. We construct the dummy variable when they answered Yes.[p]

3. Information Spillover from Training Participants to Non-Training Participants

We also study possible information spillovers from training participants to non-participants by looking at how farmers connect with training participants upon returning from training and whether these connections have any impact upon agroforestry adoption. For this estimation, separate regressions are employed, one for all farmers in general and one exclusively for non-training participants. We define networks with training participants post-training as farmers' agricultural advice networks that include those who attended the training. Farmers were asked from whom they obtain information pertaining to farming practices, and then we determined whether those mentioned individuals had been selected to attend the training and had actually attended the training. This network variable may possibly be endogenous because those with more diverse networks may be influential and thus have already had more networks to begin with. In the estimation model, social networks containing training participants were

[n] The details on variable construction can be found in the supplementary materials.

[o] .

[p] While we understood that the dummy variable construction might not be sufficient to capture the actual benefits of agroforestry, this is the best that we could do to examine these variables in the survey. Measuring agroforestry benefits related to the environment, i.e., the carbon sequence or the soil fertility, would require much more resources than previously estimated.

instrumented with social networks with farmers invited to the training because training status is randomized.

4. Farmers' Social Networks

For social network variables, we distinguished different type of social networks, namely networks with peers, in this case, fellow farmers, and networks with agricultural specialists, or extension officials. We also investigated training participants' social networks after returning from the training to see whether they enlarged their network coverage. During the survey, we asked farmers 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; using this information, we later constructed personal network variables as follows:

a. Advice network of training participants upon returning from training

Farmers tend to talk with other farmers regarding farming activities, particularly with members of their farmers group. First, we asked farmers all the name of such people until they mentioned 20 at most. Afterwards, we collected more information regarding such contacts, including number of years knowing the people, main mode of contact, frequency of meeting, and even where these people live if they do not belong to the same farmer group. Then according to the ID of such contacts, we identified whether those people belonged to the same training group as the training participants, different training group, or even whether these people did not go to the training at all.

b. Social network with agricultural experts

Apart from the abovementioned advice network, we asked farmers about their personal contacts: whether they know any extension agent. Extension agents are regarded as more advanced sources of information than fellow farmers and are readily accessible for consultation. If farmers know an extension official personally, they have a better chance to get new information. Knowing means mutual acquaintanceship, so if they state that they know an extension agent, they must be able to contact that person directly

c. **Social network with peers**

Furthermore, data on farmers' agricultural information sources were collected, which considered people from both within their farmer's group and outside the farmer's group using the same question about social networks. The frequency of meeting with these people was also examined to determine whether training had had any impact to expand and intensify farmers' social networks.

5. **Income smoothing**

We use coefficient of variation (CV) of farmers' farm income for a three-year timespan as a proxy variable for income smoothing. While the three consecutive years of examination of income might not be enough to detect smoothing, they may still serve as an indication of income vulnerabilities in the shorter term. We faced limitations in our ability to acquire a longer dataset to gain a more robust indication of smoothing. The Coefficient of Variation is a distribution's standard deviation divided by its mean.

5.2. Estimation Strategy

The difficulty in impact evaluation comes from the fact that comparing the same individual over time will not give a reliable estimate because the real impact of the program is the difference between the post-program outcome and the hypothetical outcome that this individual would have obtained had she not been treated (which may well be different from her pre-program outcome). To proxy this hypothetical outcome, we can use the pre-and post-program difference of the control group who were not exposed to the treatment, conditioning that unobserved heterogeneity between the two groups are time-invariant (see Duflo, Glennerster, and Kremer (2007)). The ideal way to deal with the problem of counterfactuals is to employ RCTs, which involve the random assignment of eligible individuals to either a treatment or comparison group. In doing so, any difference in an indicator of impact can be attributed to the intervention.

In this study, we employed an RCT and randomized the invitation to the training program. However, even if we randomize the invitation, the decision to participate lies entirely with the individuals and if there are unobserved characteristics that affect the decision to participate as well as the outcome (such as “willingness to work hard”), it would violate one of the necessary assumptions for the OLS (i.e., cov(X,u)=0). Thus, we instrument the training participation status with the randomization result to show the Local Average Treatment Effect (LATE), which shows the effect of compliers only. We further employ panel data to account for time-invariant unobserved heterogeneity across observations and conduct the Fixed-Effects Instrumental Variable regressions:

$$Y_{i,t} = \beta_0 + \beta_1 W_i * T_t + \beta_2 W_i * T_t * P_{i,2012} + \beta_3 W_i * P_{i,2012} + \beta_4 T_t + \square Crop\ Category\ Dummy_{i,t} + u_i + \varepsilon_{i,t} \quad (1)$$

W_i (training participation, treatment dummy) is endogenous because it may be correlated with u_i. Thus, we will employ an instrument Z_i (which is randomized training invitation) that is uncorrelated with u_i but correlated with W_i. T_t equals to one if it is post-training and zero otherwise and $P_{i,2012}$ represents the dummy of individual with below-median farm income in the baseline year. $\square Crop\ Category\ Dummy_{i,t}$ is the list of crop category dummy variables which is time-variant, whereas u_i represent the individual-specific fixed-effects. Our main interests are β_1 and β_2 to see the effects of training and the heterogenous effect of the training for the poor upon the dependent variables.

In order to examine the effects of agroforestry on income smoothing, we use the coefficient of variation of farm income as dependent variable and agroforestry index as independent variables. We employ pooled ordinary least square (OLS) for this estimation. However, because the decision to adopt agroforestry practices depends on farmers and thus may be endogenous to the model, we instrument it with randomized training invitation.

6. RESULTS

6.1. Difference-In-Difference Results

(Table 3 here)

Table 3 illustrates the main dependent variables examined in the study. Before the training, the treatment group, which is defined by random training invitation (Z), generally cultivated more crops by category than the control group. In 2 consecutive years after the training (in 2013 and 2014 respectively for almost all of the dependent variables except the agroforestry perception which is available only in 2013), both the treatment and control group show increases in both agroforestry indices, yielding D-I-D estimates that are not statistically significant. Furthermore, treatment groups' networks contained more non-participants post-training. The treatment group is also considered more stable in their income. The D-I-D results show that treatment groups are more knowledgeable regarding agroforestry benefits and experienced them, and they seemed to significantly decrease their income coming from leguminous crops.

6.2. Training Effects on Agroforestry Index

(Table 4 here)

We estimate the general training's effects on agroforestry index by category and diversity based on the FE-IV model. In Table 4, columns 1 and 3 shows general training's effects on the agroforestry index whereas columns 2 and 4 present training's effects according to income heterogeneity. **We found that training had no significant effects on general participants' agroforestry index by crop category and crop diversity, contrary to our first hypothesis**. This may possibly be due to the increase in the crop category and diversity index exhibited by all farmers, including non-participants, via spillover effects. However, when income heterogeneity is taken account, we found different attitudes between the poor and non-poor. In columns 2, we find that the training has negative effects on the agroforestry index by category for the non-poor by 0.45 points whereas almost no effect for the poor (-0.45 + 0.50 = 0.05). The negative effect for the non-poor is not substantial enough to also yield a statistically significant effects for the full sample. In column 4 however, we found a positive training effect for the poor upon increasing agroforestry index by diversity while no effects for the non-poor. The findings seem to show that the non-poor reduce the number of crop categories but not the diversity, while the poor increase the diversity of crops but do not expand to other crop categories.

While larger farms are more diversified to begin with [see Culas and Mahendrarajah (2005)], non-poor farmers 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 would be better served by converting their less-profitable crops to main cash crops to maximize their return. In contrast, poor training participants may possibly behave differently: they might opt to keep the same number of crops category or diversify more by crop diversity, albeit on a small scale. This may mean that (1) the poor may have become more knowledgeable regarding the benefits of diversifying their farm after the training, hence adapting their livelihood strategy to diversify their crops index by diversity upon returning from the training program, or (2) even if they intend to specialize in the main cash crops or to increase their crop index by category, they might not be able to do so due to capital and labor constraints and the risk associated with them, hence keeping the same number of crops by category as before training.

6.3. Training Effects on Perceived Benefits of Agroforestry

(Table 5 here)

We further examine whether the training was effective in changing farmers' knowledge. Table 5 shows this result, and we find strong positive effects of training on changing their perceptions of the benefits from agroforestry. Columns 1–5 and 11–15 report the training effects on perceived agroforestry benefits, and columns 6–10 and 16–20 present training's effects on perceptions according to income heterogeneity. In general, training participants experienced agroforestry benefits after practicing it, and these benefits include both economic (i.e., reducing chances of complete crop failures, provision of fuel-wood, and produce for medicinal purposes) and environmental (i.e., conserved soil and water and improved surroundings) benefits. Training participants in general testified that agroforestry adoption may help them to reduce chances of complete crop failure, regardless of income level. This may imply that farmers, regardless of income group, perceive crop diversity adoption as a way to mitigate economic risk. Looking at the effects according to income level in columns 10 and 20, we asked whether farmers experienced the benefits of agroforestry from the extraction of trees for medicinal purposes. The poor are found to particularly benefit from procuring the produce for medicinal purposes from their farmland. For instance, some traditional medicines use herb ingredients from spice crops, and poor farmers seem to have been particularly aware of this benefit, possibly due to lack of access to modern medication.

We found no effects on the rest of the perceived benefits, namely the extraction of trees for fodder, increased variety of food income, increased provision for shade trees, increased soil fertility, and increased farm income, that we do not report here. We presumed because these benefits were clear-cut thus easily observable, that farmers were already aware of these benefits even before the training, resulting from their current agroforestry practices.

Training participants generally perceive the benefits of agroforestry positively due to increased awareness from the training, by which the second hypothesis is supported. Higher-income farmers tend to experience the environmental merits of diversification, i.e., conserved soil and water, as well as economic ones, i.e., provision of fuel-wood, while lower income farmers benefit from crops with medicinal purposes. 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. This may help explain why perceptions of ecological benefits were not significant, such as the increased provision for shade trees and increased soil fertility not reported here. The effects on perceptions can reflect actual observed treatment effects but also increased awareness of benefits from pre-program agroforestry activities. There are two possible interpretations to our findings: (1) in terms of environmental benefits, agroforestry might have delivered the merits to farmers since the pre-program period, but farmers realized those merits only in the post-program period due to increased knowledge, and (2) regarding economic benefits, farmers may have somehow already realized the merits prior to the program period because economic benefits may be easier to be felt, but the program has validated their perception more strongly.

6.4. Information Spillovers from Participants to Non-participants

(Table 6 here)

The results thus far have shown that although the training was effective in changing perceptions of agroforestry for general participants, it led to the adoption of diversification only for the poor. We suspect that this may be partially due to the presence of information spillovers from training participants to non-training participants. Thus, using the sub-sample of non-participants, we examined the effects of the number of acquaintances who are participants on the outcome of agroforestry adoption in Table 6. We find significant effects of spillovers from participants to non-participants. Column 1 demonstrates that a greater number of information sources who were participants leads to an increase in the agroforestry index (i.e., adoption of more crops) after the training. We do not find this effect to be different between the poor and non-poor in column 2. From this, we can say that **training participants in general appear to help promote agroforestry practices to others, albeit with small effect, suggesting that our third hypothesis is supported.** This spillover from participants and non-participants probably reduced the differential impact of training in general, as found in Table 6, by influencing the outcomes of non-participants at the same time.

6.5. Training's Effects on Income and Social Networks

(Table 7 here)

(Table 8 here)

Although we did not find any effects from training for the general participants in Table 4, we find that the poor participants behave differently compared to the non-poor. Thus, we examine whether these poor farmers also benefited by increasing their income. Farmers' average produce sold annually and their reported incomes are given in Table 7 and Table 8, respectively. On crop production, training seems to have negative effects for the non-poor on total produce of leguminous crops in Table 7 column 4; while it seems to have no effects on the poor. The non-poor training participants also reduced the volume of industrial crops produced while the effect is negligible for the poor (column 6).

On crop income, the examination in Table 8 indicates that the non-poor see a decrease in overall income, particularly attributed by the loss from leguminous crop income (Column 6) among other crops which show negative coefficients. The poor however, tend to behave differently from the non-poor in terms of keeping the income from leguminous crops (column 6), which helped increasing the total farm income relative to the non-poor. The increase in aggregate farm income for the poor may have been attributed to the significant increase in their crop diversity index. This increase may not be fully reflected in their income from specific crop category, as the poor in fact kept the number of agroforestry index by crop category. However, considering that the poor testified the increased benefits from procuring the produce for medicinal purposes, it could also be inferred that they diversify on herbs/medicinal plants and may increase their income possibly from this produce to some extent.

We also found that generally, training participants increased their income from spice crops (Table 8, column 9). This may possibly imply that the general participants tend to switch from legume crops to spice crops because they perceived spice crops to be more profitable than legume crops. However, because it takes time for the spice crops to grow, the income for the non-poor in the first and second years cannot offset the loss of income from the legume crops that they abandoned, making their aggregate income negative compared to the poor in the first few years. Looking at the total farm income of the poor (column 2), we can infer that the positive income for the poor may have been driven by the increase in their crop diversity index that are likely to be based on their individual preferences in addition to the constant income from leguminous crops (Table 8 column 6).

(Table 9 here)

We also examine whether the training affected farmers' social networks. Training effects on various social network variables are presented in Table 9, which includes the effects on general participants and on the different income groups. The number of the network represents its size, while the intensity of meeting and contacts (frequency), is a proxy for network depth. We found that training participants in general did not expand their network post-training. However, when participants' income heterogeneity is included, poor farmers tend to communicate more with people who did not go to the training by almost 1 person (column 6). They are also found to have more agricultural informants with whom they met frequently, or once every one or two days (column 8). However, these poor farmers do not significantly increase contacts with agricultural specialists.

Only poor participants are found to have increased the size and depth of networks, indicating the third hypothesis to be only partially supported. Poorer training participants, who often are more marginalized and have less opportunity to improve their formal knowledge, may have experienced changes in their mindset and attitude after the training program. Upon returning, they are more likely to be pro-active in information gathering, thus exhibiting a significant increase in their network size relative to their non-poor counterparts. In contrast, relatively wealthy farmers are not information-constrained and therefore have little incentive to increase their investment in networks.

(Table 10 here)

Table 10 examines the correlation of agroforestry with income vulnerability. Because agroforestry variables were used in the previous sections as a dependent variable, it may be endogenous. We employ the randomized training invitation as an instrumental variable for the agroforestry variable. Columns 1, 3, and 4 show that agroforestry, according to both crop category and diversity, has significantly negative associations with farm income variation. This indicates that for each additional commodity, the income variation among farmers shrinks. Admittedly, two years of post-training income data might not be sufficient to detect smoothing, but there were limitations to acquiring a longer dataset. While the current examination in income is not enough to detect income smoothing, we believe that it may still serve as an indication of income stability in the immediate term.

The income report shows that diversification in the shorter term helps poor farmers stabilize their farm income to some extent, which is consistent with the fifth hypothesis. In the previous sections, evidences were found that poorer training participants tend to increase the number of crop by diversity but keep the number of crop indices by category. Deeper examinations discovered that, for the poor, the increased diversity index, altogether with the constant income from leguminous crops may have led to increased aggregate farm income relative to the non-poor post-training. With the shift in crop mix by category for the non-poor, the total farm income decreased for the non-poor but it increased for the poor because (1) crops planted as part of crop specialization take longer to grow; and (2) because the poor increased their crop diversity and maintained the number of crop categories relative to the non-poor.

7. DISCUSSION AND CONCLUSION

This paper aims to investigate training's effects on the adoption and perceived benefits of agroforestry practices, particularly examining differences in effects between lower and higher-income farmers. To see the adoption mechanism, various social network ties among training participants as well as interactions with peers and experts resulting from the training are examined. Information spillovers from participants to non-participants upon returning is also incorporated in the analysis.

We first found that although training in general did not have effects on agroforestry adoption, the effects nonetheless differ between the poor and non-poor. When we examine the training impacts on the perceived benefits of agroforestry, we find that both income groups fully understand the benefits of agroforestry and actually experienced them. Thus, the training itself had the expected impacts on their knowledge. However, training did not have the expected positive impact on adoption in general partly because of the presence of spillovers between participants and non-participants. Poor farmers, who were found to increase their crop diversity index in addition to maintaining their income from leguminous crops, were able to increase their total income. Poor farmers also expanded their social networks after the training. The adoption of agroforestry was also found to reduce the fluctuation of income, suggesting that poorer farmers not only benefited from higher incomes but also from lower income volatility. The non-poor however, seemed to reduce their crop category index because they opted for crop specialization strategy after the training. This resulted in reduced aggregate income within two years post-evaluation as the loss incurred from switching crop category has yet to be compensated by the new crops that takes time to grow.

Several limitations hampered our ability to more closely study training's impacts on agroforestry. First, while it would be interesting to look at the effects of different locations on different income categories, we have limitations to accommodate this possibility due to the small sample size. Training location, apart from representing distance, also accounts for the more advanced areas for coffee and cocoa cultivation, which may account for more learning experiences for a farther training location. For a possible future study, it would be interesting to see how this works for poor farmers but with a larger sample size and more multi-year data.

Second, due to the nature of agroforestry, which is heavily local-based, and the nature of RCT studies, which are known for their weakness in external validity, we cannot ensure that the results obtained here can be generalized to different training programs implemented in different contexts.

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LIST OF TABLES

Table 1: Baseline Data

Variables	All Farmers			Above Median Farm Income			Below Median Farm Income		
	Not Invited (Control)	Invited (Treated)	P-value	Not Invited (Control)	Invited (Treated)	P-value	Not Invited (Control)	Invited (Treated)	P-value
Household Characteristics									
Age of Household head	46.06 (12.04)	44.05 (11.01)	0.136	45.15 (11.7)	44.58 (10.5)	0.75	46.93 (12.38)	43.45 (11.58)	0.08
Household head Years of Education	8.43 (3.55)	8.31 (3.23)	0.610	8.67 (3.80)	8.24 (3.14)	0.45	8.41 (3.6)	8.25 (3.43)	0.77
Household size	4.20 (1.50)	4.08 (1.52)	0.50	4.20 (1.29)	4.19 (1.40)	0.96	4.2 (1.69)	3.97 (1.64)	0.39
Owned farmland	1.12 (1.06)	0.97 (0.78)	0.161	1.49 (1.29)	1.20 (0.86)	0.09	0.78 (0.64)	0.71 (0.59)	0.50
Cultivated farmland	1.06 (0.78)	1.01 (0.77)	0.60	1.36 (0.86)	1.26 (0.83)	0.45	0.77 (0.57)	0.73 (0.57)	0.66
Log of farm income	16.16 (1.31)	16.23 (1.26)	0.62	17.15 (0.56)	17.14 (0.64)	0.95	15.16 (1.08)	15.21 (0.97)	0.77
Log of non-farm income	15.64 (1.62)	15.65 (1.21)	0.93	15.62 (2.0)	15.93 (1.10)	0.36	15.65 (1.25)	15.30 (1.27)	0.19
No. of Mobile Phone	1.57 (1.21)	1.42 (1.05)	0.26	1.76 (1.26)	1.46 (1.06)	0.10	1.39 (1.15)	1.38 (1.04)	0.99
No. of Motorbike	1.25 (0.78)	1.35 (0.90)	0.31	1.40 (0.81)	1.52 (0.92)	0.38	1.12 (0.72)	1.16 (0.83)	0.72
Walking distance to farmland (in minutes)	19.62 (21.93)	24.66 (62.2)	0.35	25.2 (26.49)	18.96 (14.14)	0.13	21.7 (23.91)	18.86 (18.57)	0.49
Walking distance to paved road (in minutes)	3.16 (7.15)	3.59 (6.97)	0.59	3.50 (6.83)	3.36 (6.91)	0.89	2.84 (7.47)	3.85 (7.08)	0.39
No. of hired labor	2.91 (1.97)	3 (2.19)	0.72	3.39 (2.06)	3.5 (2.18)	0.75	2.48 (1.79)	2.44 (2.08)	0.88
Access to ROSCA (rotating credit-saving association)	0.97 (0.17)	0.98 (0.11)	0.27	0.97 (0.16)	1 (0)	0.14	0.96 (0.18)	0.97 (0.16)	0.76
Total organic	838.1 (1974.2	737.5 (968.9)	0.57	1203.16 (2709.02	996.32 (1075.2)	0.52	504.29 (752.44	450 (742.18)	0.65

fertilizer usage (in kg)	)			)			)		
Total chemical fertilizer usage (in kg)	271.2 (403.3)	287.4 (930.4)	0.84	337.33 (403.22)	391.87 (1228.67)	0.71	210.67 (396.35)	171.36 (368.13)	0.52
Network Characteristics									
Know an extension agent	0.89 (0.30)	0.87 (0.33)	0.42	0.88 (0.327)	0.925 (0.265)	0.34	0.91 (0.28)	0.80 (0.39)	0.04
No of advice network from inside the farmer group	3.6 (3.55)	3.84 (3.66)	0.55	4.06 (4.01)	4.37 (4.07)	0.63	3.17 (3.02)	3.26 (3.07)	0.84
No of advice network from outside the farmer group	1.22 (1.71)	1.46 (1.82)	0.23	1.43 (1.98)	2.02 (2.07)	0.07	1.02 (1.39)	0.84 (1.24)	0.40
Observation	156	156		74	82		82	74	

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

Table 2: *Training Participation*

	Invited by lottery				Total
	Above Median Farm Income		Below Median Farm Income		
	Participating	Non-Participating	Participating	Non-Participating	
Training in hometown	20 (12.8%)	8 (5.1%)	19 (12.1%)	5 (3.2%)	52 (33.33%)
Training in intra-island	19 (12.1%)	6 (3.8%)	20 (12.8%)	7 (4.4%)	52 (33.33%)
Training in inter-island	22 (14.1%)	7 (4.4%)	20 (12.8%)	3 (1.9%)	52 (33.33%)
Total	61 (39.1%)	21 (13.4%)	59 (37.8%)	15 (9.6%)	156(100%)
	82 (52.6%)		74 (47.4%)		

Table 3: *Summary Statistics of Dependent Variables*

Variables	All Farmers									
	Pre-treatment (Year of 2012)				Post-treatment (Year of 2013 and 2014)				Pre- vs Post-Diff	
	Not Invited (Control)	Invited (Treated)	Diff (T-C)	P-value	Not Invited (Control)	Invited (Treated)	Diff (T-C)	P-value	D-I-D	P-value
Agroforestry Index (by Category)	2.26 (1.07)	2.52 (1.13)	0.26	0.022	2.74 (0.97)	2.78 (0.94)	0.044	0.587	-0.218	0.121
Agroforestry Index (by Diversity)	3.06 (1.65)	3.22 (1.45)	0.16	0.312	3.49 (1.34)	3.46 (1.27)	0.023	0.835	-0.184	0.344
Network with training participants from same group	0 (0)	0.44 (0.79)	0.44	0.000	0 (0)	0.35 (0.62)	0.35	0.000	-0.095	0.153
Network with training participants from different group	0 (0)	0.69 (0.92)	0.69	0.000	0 (0)	0.59 (0.97)	0.59	0.000	-0.102	0.273
Network with non-training participants	3.40 (3.0)	3.89 (3.45)	0.486	0.105	3.04 (2.12)	3.41(2.43)	0.370	0.080	-0.115	0.753
Number of frequently met agricultural informants	3.20 (3.47)	3.30 (3.38)	0.099	0.76	1.37 (2.45)	1.50 (2.54)	0.124	0.59	0.024	0.952
Network with training participants	1.43 (1.70)	1.38 (1.28)	-0.041	0.787	1.09 (1.21)	1.14 (1.22)	0.046	0.672	0.087	0.641
Log of farm income	16.16 (1.31)	16.23 (1.26)	0.073	0.611	16.02 (1.23)	16.10 (1.19)	0.076	0.470	0.003	0.986
Coefficient of variation	67.62 (38.07)	57.1 (36.27)	-10.5	0.014	67.62 (38.0)	57.11 (36.2)	-10.5	0.001	0	1.000
Log of Cereal Crop Production	0.75 (2.15)	0.44 (1.72)	-0.31	0.153	0.819 (2.23)	0.31 (1.42)	-0.509	0.000	0.199	0.452
Log of Legume Crop Production	0.181 (0.977)	0.49 (1.533)	0.311	0.006	0.13 (0.88)	0.10 (0.742)	-0.027	0.733	-0.338	0.015
Log of Industrial Crop Production	5.174 (2.34)	5.496 (1.92)	0.322	0.225	5.241 (2.60)	5.119 (2.22)	-0.122	0.515	-0.444	0.172
Log of Spices Crop Production	2.290 (2.55)	2.128 (2.43)	-0.162	0.565	2.435 (2.67)	2.336 (2.20)	-0.100	0.616	0.062	0.857
Log of Vegetable Crop Production	0.040 (0.507)	0.181 (1.13)	0.141	0.139	0.000 (0)	0.18 (1.17)	0.180	0.008	0.039	0.740
Log of Fruit Crop Production	2.867 (3.315)	3.53 (3.56)	0.665	0.075	5.003 (3.3)	5.355 (3.10)	0.352	0.182	-0.313	0.494
Log of Hardwood Production	0.00 (0)	0.000 (0)	0.00	1.00	0.06 (0.477)	0.07 (0.666)	0.016	0.667	0.016	0.804
Log of Cereal Crop Income	1.68 (4.75)	0.92 (3.72)	-0.760	0.118	1.87 (4.98)	0.665 (3.04)	-1.21	0.0003	0.454	0.435
Log of Legume Crop Income	0.489 (2.49)	1.40 (4.14)	0.92	0.017	0.307 (2.06)	0.364 (2.22)	0.056	0.741	-0.864	0.018
Log of Industrial Crop Income	13.52 (5.27)	14.30 (4.19)	0.77	0.154	13.24 (5.44)	13.60 (5.06)	0.36	0.390	-0.411	0.56
Log of Spices Crop Income	7.42 (7.82)	7.09 (7.65)	-0.332	0.705	8.59 (7.39)	9.01 (7.26)	0.412	0.482	0.080	0.938
Log of Vegetable Crop Income	0.083 (1.05)	0.379 (2.32)	0.29	0.146	0 (0)	0.350 (2.29)	0.350	0.006	0.054	0.815
Log of Fruit Crop Income	5.93 (6.69)	7.12 (6.97)	1.19	0.12	9.65 (6.17)	10.52 (5.88)	0.871	0.072	-0.319	0.715
Log of Hardwood Income	0.091 (1.15)	0 (0)	0.091	0.329	0.332 (2.23)	0.171 (1.49)	-0.161	0.291	0.070	0.75
Observation	156	156			312	312				
Improved Surrounding	0.78 (0.415)	0.81 (0.394)	0.029	0.509	0.77 (0.419)	0.88 (0.324)	0.108	0.015	0.079	0.210
Reducing Chances of Complete Crop Failure	0.553 (0.49)	0.467 (0.50)	-0.086	0.129	0.465 (0.50)	0.520 (0.)	0.054	0.339	0.141	0.080
Conserved Soil and Water	0.40 (0.49)	0.36 (0.48)	-0.040	0.468	0.53 (0.50)	0.63 (0.48)	0.097	0.082	0.137	0.081
Provision for fuelwood	0.82 (0.38)	0.82 (0.38)	-0.002	0.97	0.67 (0.46)	0.77 (0.41)	0.097	0.040	0.099	0.139
Provision for medicinal purposes	0.18 (0.38)	0.11 (0.31)	-0.071	0.08	0.11 (0.33)	0.19 (0.39)	0.071	0.079	0.142	0.014
Know extension agent	0.89 (0.30)	0.86 (0.33)	-0.030	0.418	0.87 (0.33)	0.88 (0.31)	0.009	0.814	0.038	0.458
Observation	156	156			156	156				

Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. For the agroforestry-benefit perception variables, the post-treatment is available only for the year of 2013.

Table 4: *Training Effects on Agroforestry Index*

	Agroforestry Index by Category		Agroforestry Index by Diversity	
VARIABLES	(1)	(2)	(3)	(4)
Training*Post-2013	-0.202	-0.445**	-0.145	-0.407
	(0.152)	(0.192)	(0.198)	(0.248)
Training*Post-2013*Low Income		0.496**		0.535*
		(0.216)		(0.280)
Year of 2013	0.631***	0.631***	0.685***	0.685***
	(0.0908)	(0.0907)	(0.118)	(0.118)
Year of 2014	0.279***	0.279***	0.107	0.107
	(0.0905)	(0.0904)	(0.117)	(0.117)
Constant	2.292***	2.285***	3.041***	3.034***
	(0.116)	(0.116)	(0.151)	(0.151)
Village Fixed-Effects	YES	YES	YES	YES
Farmers Group Fixed-effects	YES	YES	YES	YES
Observations	926	926	926	926
Number of ID	311	311	311	311
R-Squared	0.102	0.106	0.0954	0.0999

Estimation is based on Fixed-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 result. Village dummies and crop category dummies are included but not shown for brevity.

Table 5: *Training Effects on Perceived Benefits of Agroforestry if Practicing It*

VARIABLES	If planting more than one crop category										If planting more than one crop type									
	Improved Surrounding	Reduced Crop Failure	Conserved Soil and Water	Extraction for Fuelwood	Extraction for Medicinal Purposes	Improved Surrounding	Reduced Crop Failure	Conserved Soil and Water	Extraction for Fuelwood	Extraction for Medicinal Purposes	Improved Surrounding	Reduced Crop Failure	Conserved Soil and Water	Extraction for Fuelwood	Extraction for Medicinal Purposes	Improved Surrounding	Reduced Crop Failure	Conserved Soil and Water	Extraction for Fuelwood	Extraction for Medicinal Purposes
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Training * Post 2013	0.137*	0.284**	0.267**	0.185**	0.303***	0.103	0.200	0.293**	0.254**	0.187	0.117	0.238**	0.234**	0.147*	0.222**	0.0667	0.150	0.232*	0.206**	0.0887
	(0.0793)	(0.128)	(0.115)	(0.0875)	(0.0966)	(0.0970)	(0.156)	(0.140)	(0.106)	(0.118)	(0.0726)	(0.121)	(0.108)	(0.0814)	(0.0925)	(0.0905)	(0.150)	(0.134)	(0.101)	(0.115)
Training * Post 2013 * Low Income						0.0781	0.195	-0.0611	-0.160	0.270**						0.109	0.191	0.00360	-0.127	0.287**
						(0.112)	(0.180)	(0.163)	(0.123)	(0.136)						(0.103)	(0.171)	(0.152)	(0.115)	(0.131)
Year of 2013	-0.0285	-0.144*	0.120*	-0.180***	-0.0975*	-0.0284	-0.144*	0.120*	-0.180***	-0.0971*	-0.0212	-0.107	0.110*	-0.161***	-0.0681	-0.0211	-0.107	0.110*	-0.161***	-0.0679
	(0.0468)	(0.0752)	(0.0677)	(0.0516)	(0.0570)	(0.0469)	(0.0752)	(0.0679)	(0.0514)	(0.0569)	(0.0432)	(0.0719)	(0.0640)	(0.0484)	(0.0550)	(0.0432)	(0.0718)	(0.0642)	(0.0484)	(0.0550)
Constant	0.758**	0.125	0.515	1.072***	-0.0607	0.763**	0.138	0.511	1.061***	-0.0424	0.783**	0.261	0.342	1.127***	-0.121	0.791**	0.276	0.343	1.117***	-0.0988
	(0.329)	(0.529)	(0.477)	(0.363)	(0.401)	(0.330)	(0.529)	(0.478)	(0.362)	(0.400)	(0.314)	(0.523)	(0.465)	(0.352)	(0.400)	(0.314)	(0.522)	(0.466)	(0.352)	(0.400)
Crop Category Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	511	511	511	511	506	511	511	511	511	506	544	544	544	544	544	544	544	544	544	544
Number of ID	292	292	292	292	289	292	292	292	292	289	300	300	300	300	300	300	300	300	300	300
R-Squared	0.0235	0.0307	0.128	0.0697	0.0836	0.0243	0.0357	0.129	0.0817	0.0903	0.0206	0.0391	0.128	0.0768	0.0714	0.0241	0.0454	0.128	0.0832	0.0766

Estimation is based on Fixed-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 result. Crop category dummies are included but not shown for brevity.

Table 6: *Information spillover from training participants to non-training participants*

VARIABLES	Agroforestry Index (by Crop Category)		Agroforestry Index (by Crop Diversity)	
	(1)	(2)	(3)	(4)
No of Information Source who are Training Participants *Post2013	0.0347***	0.0475***	0.0403	-0.00409
	(0.0128)	(0.0156)	(0.0488)	(0.0594)
No of Information Source who are Training Participants and Belong to Low Income Category * Post 2013		-0.0268		0.0972
		(0.0180)		(0.0687)
No of Information Source who are Training Participants	-0.0108	-0.00760	-0.0301	-0.0277
	(0.00981)	(0.0124)	(0.0374)	(0.0475)
No of Information Source who are Training Participants and Belong to Low Income Category		-0.00555		-0.0113
		(0.0168)		(0.0641)
Year of 2013	-0.0125	-0.0115	0.00358	-0.00188
	(0.0249)	(0.0248)	(0.0948)	(0.0946)
Year of 2014	-0.00406	-0.00424	-0.190**	-0.192**
	(0.0238)	(0.0237)	(0.0906)	(0.0905)
Constant	0.0160	0.0179	0.134	0.137
	(0.0611)	(0.0610)	(0.233)	(0.233)
Crop Category Dummy	YES	YES	YES	YES
Village Fixed-effects	YES	YES	YES	YES
Observation	549	549	548	548
No of ID	192	192	191	191
R-Squared	0.971	0.971	0.753	0.755

Estimation is based on Fixed-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 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. Village Fixed-Effects, Crop Category Dummy, Age and years of education of household head as well as cultivated farmland (in Log) are included but not reported for brevity.

Table 7: *Effects of Training on Agricultural Produce Sold (in Log of Kg)*

VARIABLES	Log of Produce Sold (in Kg)													
	Cereal Crops		Leguminous Crops		Industrial Crops		Spice Crops		Vegetable Crops		Fruit Crops		Hardwood	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Training * Post 2013	-0.299	-0.487	-0.367***	-0.515***	-0.437	-0.943**	0.246	0.391	-0.0332	-0.0774	-0.0251	-0.269	0.0243	-0.00772
	(0.261)	(0.329)	(0.128)	(0.162)	(0.325)	(0.411)	(0.288)	(0.364)	(0.106)	(0.133)	(0.350)	(0.442)	(0.0835)	(0.105)
Training * Post 2013 * Low Income		0.376		0.296		1.016**		-0.290		0.0887		0.490		0.0643
		(0.373)		(0.183)		(0.465)		(0.412)		(0.151)		(0.500)		(0.119)
Year of 2013	0.0648	0.0672	-0.0794	-0.0775	0.304	0.310	-0.00179	-0.00365	0.0481	0.0486	0.721***	0.725***	0.0776	0.0780
	(0.164)	(0.165)	(0.0808)	(0.0809)	(0.205)	(0.205)	(0.182)	(0.182)	(0.0666)	(0.0666)	(0.221)	(0.221)	(0.0526)	(0.0527)
Year of 2014	0.0170	0.0155	0.0531	0.0519	-0.164	-0.168	-0.651***	-0.650***	0.00803	0.00768	0.947***	0.945***	0.0127	0.0124
	(0.163)	(0.163)	(0.0801)	(0.0801)	(0.203)	(0.203)	(0.180)	(0.180)	(0.0660)	(0.0659)	(0.219)	(0.218)	(0.0521)	(0.0521)
Constant	0.985***	0.978***	0.0599	0.0549	2.357***	2.340***	1.291***	1.295***	0.143	0.141	1.154**	1.146**	-0.0338	-0.0349
	(0.349)	(0.349)	(0.171)	(0.171)	(0.435)	(0.435)	(0.385)	(0.385)	(0.141)	(0.141)	(0.468)	(0.468)	(0.112)	(0.112)
Crop Category Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	926	926	926	926	926	926	926	926	926	926	926	926	926	926
No of ID	311	311	311	311	311	311	311	311	311	311	311	311	311	311
R-Squared	0.250	0.250	0.424	0.425	0.113	0.112	0.365	0.367	0.415	0.417	0.485	0.487	0.0432	0.0447

Estimation is based on Fixed-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. Crop category dummies are included but not reported for brevity.

Table 8: *Effects of Training on Agricultural Income According to Type of Produce (in Log of Indonesian Rp)*

VARIABLES	Log of Income															
	All Crops Combined		Cereal Crops		Leguminous Crops		Industrial Crops		Spice Crops		Vegetable Crops		Fruit Crops		Hardwood	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Training * Post 2013	0.0106	-0.555**	-0.685	-1.046	-0.942***	-1.431***	-0.167	-0.662	1.637**	2.950***	-0.0959	-0.176	0.389	0.0246	-0.0337	-0.0815
	(0.175)	(0.217)	(0.562)	(0.710)	(0.327)	(0.413)	(0.675)	(0.854)	(0.774)	(0.972)	(0.214)	(0.269)	(0.649)	(0.819)	(0.286)	(0.361)
Training * Post 2013 *		1.140***		0.725		0.983**		0.994		-2.638**		0.162		0.732		0.0959
Low Income		(0.242)		(0.804)		(0.468)		(0.966)		(1.100)		(0.305)		(0.927)		(0.409)
Year of 2013	-0.113	-0.112	0.386	0.386	-0.170	-0.170	-0.396	-0.396	1.766***	1.766***	-0.00697	-0.00697	3.608***	3.608***	0.403**	0.403**
	(0.106)	(0.105)	(0.386)	(0.386)	(0.251)	(0.251)	(0.434)	(0.434)	(0.636)	(0.636)	(0.165)	(0.165)	(0.504)	(0.504)	(0.175)	(0.175)
Year of 2014	-0.0826	-0.0837	-0.0661	-0.0661	-0.203	-0.203	-0.161	-0.161	0.666	0.666	-0.163	-0.163	4.039***	4.039***	0.0958	0.0958
	(0.109)	(0.107)	(0.385)	(0.385)	(0.251)	(0.250)	(0.432)	(0.433)	(0.634)	(0.634)	(0.164)	(0.164)	(0.503)	(0.502)	(0.175)	(0.175)
	16.06***	16.04***	2.008***	1.992***	-0.0530	-0.0771	14.35***	14.34***	6.095***	6.112***	0.243	0.241	5.038***	5.011***	0.000747	-0.00288
	(0.138)	(0.136)	(0.495)	(0.494)	(0.322)	(0.322)	(0.555)	(0.556)	(0.814)	(0.814)	(0.211)	(0.211)	(0.646)	(0.646)	(0.224)	(0.224)
Crop Category Dummy	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	853	853	926	926	926	926	926	926	926	926	926	926	926	926	926	926
No of ID	309	309	311	311	311	311	311	311	311	311	311	311	311	311	311	311
R-Squared	0.0678	0.0961	0.252	0.253	0.442	0.444	0.145	0.143	0.492	0.498	0.403	0.404	0.509	0.511	0.0626	0.0629

Estimation is based on Fixed-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. Crop category dummies are included but not reported for brevity.

Table 9: *Training Effects on Social Networks*

VARIABLES	Only for Training Participants						All Farmers			
	No of agricultural informants who went to the same training location		No of agricultural informants who went to the different training location		No of agricultural informants who did not go to the training (may or may not be farmers)		No of agricultural informants whom respondent meets at least once every 1-2 days		Knowing extension agent (=1 if Yes)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Training * Post 2013	0.00116	-0.00236	-0.0206	-0.149	0.389	-0.150	-0.0717	-0.900	0.0339	-0.0399
	(0.0865)	(0.113)	(0.105)	(0.137)	(0.312)	(0.405)	(0.442)	(0.558)	(0.0649)	(0.0807)
Training * Post 2013 * Low Income		0.00717		0.262		1.096**		1.676***		0.152*
		(0.149)		(0.180)		(0.532)		(0.626)		(0.0912)
Year of 2013							-0.413	-0.414	-0.0200	-0.0200
							(0.264)	(0.263)	(0.0361)	(0.0360)
Year of 2014	-0.244***	-0.244***	-0.261**	-0.261**	-1.597***	-1.597***	-3.228***	-3.227***		
	(0.0857)	(0.0859)	(0.104)	(0.104)	(0.309)	(0.307)	(0.267)	(0.266)		
Constant	0.560***	0.560***	0.946***	0.943***	3.719***	3.706***	2.845***	2.861***	0.777***	0.778***
	(0.0684)	(0.0686)	(0.0829)	(0.0827)	(0.247)	(0.245)	(0.360)	(0.358)	(0.0513)	(0.0512)
Village Fixed-Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	357	357	357	357	357	357	899	899	622	622
No of id	119	119	119	119	119	119	311	311	311	311
R-Squared	0.0439	0.0439	0.0425	0.0511	0.111	0.126	0.338	0.344	0.0213	0.0306

Estimation is based on Fixed-Effects Instrumental Variable models. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively. Training dummy is instrumented by lottery result. Village dummies are included but not reported for brevity.

Table 10: *Impact of Agroforestry on Farm Income Coefficient of Variation (CV)*

	CV of Farm Income			
VARIABLES	(1)	(2)	(3)	(4)
Agroforestry Index by Category	-78.80*			
	(43.82)			
Dummy Agroforestry by Category (= 1 if having more than 1 crop index)			-235.8*	
			(137.4)	
Agroforestry Index by Diversity		-170.3		
		(261.1)		
Dummy Agroforestry by Diversity (= 1 if having more than 1 crop variety)				-251.4*
				(128.9)
Year of 2013	40.96*	94.02	40.27*	32.27*
	(22.88)	(142.8)	(23.58)	(16.91)
Year of 2014	12.15	-10.22	34.66*	28.57*
	(8.606)	(27.13)	(19.97)	(14.71)
Years of Education of Household Head	-0.772	0.431	-0.812	0.600
	(0.890)	(2.494)	(0.941)	(0.872)
Cultivated Farmland	7.227	44.07	3.336	3.726
	(6.974)	(74.13)	(5.380)	(4.898)
Possession of Motorcycle	-0.281	3.287	2.138	1.113
	(3.975)	(14.43)	(5.002)	(4.062)
Possession of Mobile Phone	-1.334	11.43	-0.573	1.406
	(2.846)	(22.51)	(3.102)	(3.220)
Constant	255.0**	537.9	240.0**	256.2***
	(99.83)	(708.2)	(95.85)	(92.68)
P-value of invitation status in the 1st stage of regression	0.057	0.518	0.070	0.041
F-Statistics in the 1st stage of regression	9.74	12.38	8.76	9.51
Observations	859	859	859	859

Estimation is based on Instrumental Variable model. Agroforestry Index by Category and its dummy, as well as Agroforestry Index by Diversity and its dummy are instrumented with randomized invitation status. Standard errors are in parentheses. ***, **, and * signify statistical significance at the 1%, 5% and 10% level, respectively.

LIST OF FIGURE

Figure 1: Income Distribution in 2012 (Baseline)