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Farmer's use of homegardens in Indonesia

A quantitative sustainable livelihood approach

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Abstract

This paper contributes to the understanding of homegardens as a livelihood strategy and its relationship with certain livelihood assets, in the current context of increasing food demand and environmental challenges faced by farmers. The sustainable livehood approach was used to analyze the main economic factors influencing homegarden use, and it was complemented by literature of technology adoption. Data from over 200 Indonesian fruit farmers was used to test the significance of the factors. A hurdle model was applied to this data to determine which combination of livelihood assets (human, natural, locational, social and financial) explain the decision to use or not a homegarden farming system, and to what extent. The econometric results show that farmer's education, amount of available land, their interacting effect, and being located in Kediri site are the main economic factors explaining the probability that homegardens are used by the farmers. Moreover, labor and land availability, distance to markets and being located in Magetan are the main factors that determines homegardens extension. From a livelihood perspective, the main livelihood assets that influence homegarden livelihood strategy are the human, natural and locational assets. The results imply a late stage in the learning process of homegarden use, confirming this practice as a traditional farming system in Indonesia. Understanding the factors influencing farmers' decisions is relevant to facilitate innovation towards more sustainable agricultural systems, such as homegardens, to promote on farm conservation practices, and finally to maintain the benefits from agro-biodiversity.

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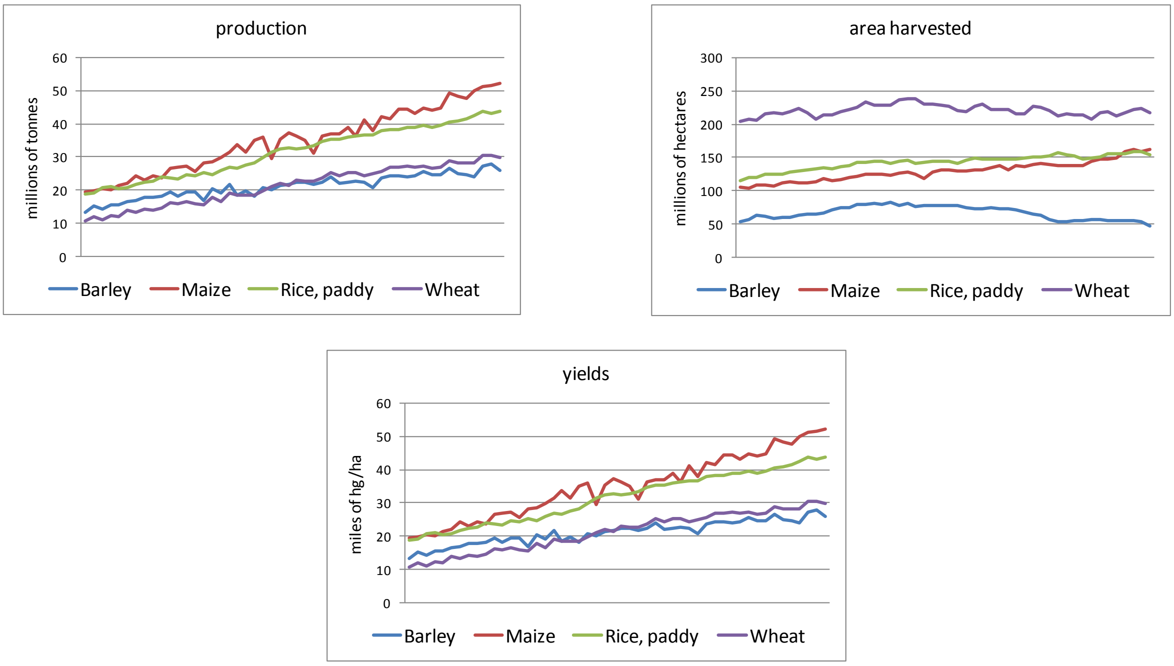
1. Introduction

1.1. Agro-biodiversity and farmer’s future challenges

By the second half of the 20th century the so called “Green Revolution” transformed the agricultural sector. Since that time, agricultural production has reached unprecedented levels. Below Graph 1 show how major crops such as maize, rice, wheat and barley have multiplied. In the case of maize even five times between 1961 and 2010. This has been caused mainly by the increase in high yielding varieties combined with an expanded use of modern chemical fertilizers and pesticides. In turn, this has brought enormous benefits: farmer’s income has been raised, nutrition has been improved and hunger has been reduced (Hazell, 2002, Tilman et al., 2002, Dethier and Effenberger, 2011).

Current agricultural practices may have also resulted in an increased environmental degradation. This occurs when the agricultural practices involve highly simplified and disturbed agro-ecosystems. As a consequence, there is a high presence of dominant crops under monoculture systems (barley, maize, rice and wheat). In Graph 1 the increasing yields of these crops explain the higher levels of production while the area harvested has remained relatively stable. This more “modern agriculture” have replaced natural ecosystems that once contained a diversity of plant and insect species.

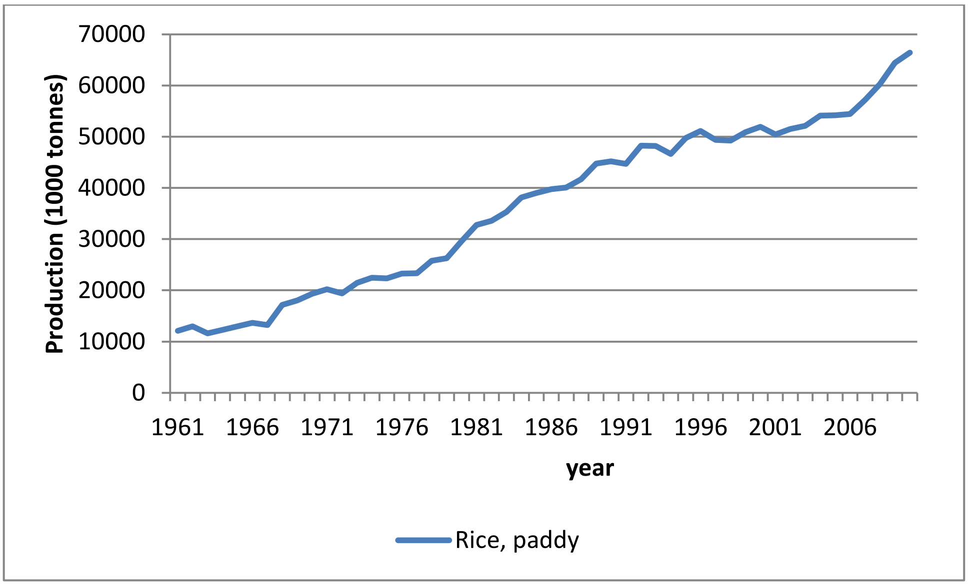
Graph 1 World agricultural indicators for major crops (1961-2010)



Source: (FAO, 2012)

Indonesia did not escape from this trend where the introduction of new high yield varieties changed their food supply, and the intensification of agricultural production plus fertilizer subsidies have increased soil fertility losses (Soemarwoto and Conway, 1992, World Bank, 2010). Between 1968 and 1992 Indonesian agriculture grew in an impressive way due to the Green Revolution (Fuglie, 2004) through the diffusion of high-yielding varieties of food crops, especially rice (Fuglie, 2010). One of the effects of the Green Revolution was that Indonesia's rice production has grown from 12 million tons in the beginning of the 1960s to over 66 million tons in 2010 (see Graph 2). The rural development that agriculture brought did not end with it. Much of the concurrent spending on roads, electrification, market-places, schools and public health also took place in rural areas, where more than 70% of the population lived (Henley, 2012). However, it also produced negative effects, such as, pest and disease outbreaks, and loss of communal social capital (Conway, 1987).

Graph 2 Rice production quantity in Indonesia (1961-2010)



Source: (FAO, 2012)

Biodiversity within agro-ecosystems, or the so called agro-biodiversity, is a subset of natural biodiversity which encompasses the variety of plants and animals, micro-organisms, genetic resources, and the ways that farmers use them (Galluzzi et al., 2010, Thrupp, 2000). The Convention on Biological Diversity (CBD) defines agro-biodiversity as “all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agro-ecosystem: the variety and variability of animals, plants and microorganisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes”(CBD, 2010).

Agricultural biodiversity is essential to the world for three main functions: sustainable production of food and other agricultural products, including providing valuable genetic resources for the improvement of future new crop varieties; biological support to production via, for example soil biota, pollinators, and predators; ecological services provided by agro-ecosystems, such as recycling of nutrients, control of local microclimate, landscape protection, soil protection and health, water cycle and quality, air quality (Altieri, 1999, Cromwell et al., 1999). Agro-biodiversity also plays a key role in the livelihoods of semi-subsistence farmers regardless of their endowments or geographical location. It provides the basic resources farmers need for food security and to adapt to varying conditions, to increase productivity and resilience, to minimize risks, and to diversify and generate income in a more efficient way (Thrupp, 2000, Galluzzi et al., 2010). There is a very close relationship between biodiversity and the livelihoods and well-being of agricultural communities (Lockie and Carpenter, 2010).

Agricultural practices determine not only the level of food production but, to a great extent, the state of the global environment (Tilman et al., 2002). Human society receives many benefits from biodiversity, such as food, fiber, fuel, medicines, fresh water among others. Consequences of current practices in agriculture can be associated with the loss of this biodiversity, the reduction of the provision of its benefits and the pollution of terrestrial ecosystems through the use of environmentally harmful amounts of nitrogen and phosphorus. Simplification and homogenization of agro-ecosystems, serious degradation of natural resources, including soils, water and biodiversity is already occurring in and around agricultural land (Thrupp, 2000). Consequently, given the fact that the ability of ecosystems to provide these goods and services depends on its number and type of species and varieties, practices that change species composition or reduce biodiversity also diminish the goods and services ecosystems provide to humans (Tilman et al., 2002). The main consequence of biodiversity loss is the change in the flow and nature of these ecosystem services in agro-ecosystems, which can become relatively less resilient and more vulnerable to diseases and pests (Boyce, 2004, Pascual and Perrings, 2007, Tilman, 1999).

Population keeps growing, and with it, food demand. On the other side, food producers are facing an increasing competition for scarce resources and with it, even more environmental challenges. Everything can get worse if climate change and its effects are taken into account. Climate change and food security could be considered the twin grand challenges for humanity in the 21st century (Godfray et al., 2011). Agricultural degradation will negatively impact future productivity of crop lands and therefore pose tremendous challenges to meet the growing demand for food (Thrupp, 2000, Galluzzi et al., 2010). These new challenges will especially affect farmers who should produce more food with a higher quality and preserving the natural resource base (Bellon, 1996, FAO, 2010).

Agriculture plays a key role between food security and climate change challenges. Climate change is likely to affect negatively agriculture practices in developing countries (Rosenzweig and Parry, 1994). Likewise, agriculture is the basis for food production (Thrupp, 2000) which together with food distribution and food consumption become important issues when dealing with food security. In particular, food production from smallholder farms is essential for global food security because the majority of poor and hungry people who depends of agriculture for their subsistence work in small farms in developing countries (Tscharntke et al., 2012). Through agriculture, climate change is threatening food security especially in the more vulnerable areas (Arndt et al., 2012). Climate change adaptation strategies involve a more sustainable and resilient agricultural systems. It has been stated previously, agro-biodiversity increases resilience of ecosystems so they can face environmental changes. In the current context of food security and climate change, conservation of agro-biodiversity becomes essential.

Conservation strategies should not overlook agricultural landscapes and focus only on pristine forests (Perfecto and Vandermeer, 2008). There are a variety of diverse, low input farming systems using agro-ecological principles that have been shown to be generally more biodiversity-friendly than modern farming systems (Bengtsson et al., 2005). This type of practices should be identified and farmers should receive incentives to continue these practices, especially in the context of climate change adaptation.

It is possible to analyze this problem at a microeconomic level. The driver that influences changes in agro-biodiversity has been individual farmer's decisions, as agro-ecosystems exist "by the grace of humankind" in the first place (Moonen and Bàrberi, 2008), p. 9). However, the impact on agro-biodiversity has consequences for ecosystem services at larger scales. Since the social benefits of high levels agro-biodiversity are not rewarded by the market, farmers have no incentive to take them into account. In addition, certain policies and institutional effects, which are not under control of the farmers, are reducing the incentives to invest in biodiversity conservation (Pascual and Perrings, 2007).

There is also evidence that show that farmers do keep a lower bound of agro-biodiversity conservation investments (Brush et al., 1992, Brush, 1995). This is because farming communities have traditionally used and preserved their own knowledge about crop varieties and have adopted technologies which help them to adapt the ecological processes of agro-ecosystems to their own needs satisfaction. Therefore, it is likely that farmers may adopt on farm conservations strategies in different levels.

The paper is organized as follows. The next section continues this brief introduction and describes what is defined as on farm conservation and homegarden systems. In section 1.3 research objectives and questions are presented. Then, in chapter 2 the theoretical framework for the analysis of homegarden use is explained. This framework is based in the sustainable livelihood approach, and techonology adoption literature complements it. In section 2.3 the conceptual model is presented which is the basis for the empirical analysis that follows. Chapter 3 presents the methodology. It includes a description of the research context and the data to be analyzed in section 3.1, the dependent and explanatory variables in section 3.2, and the econometric model chosen in section 3.3. Chapter 4 presents the estimation results and discussion comparing previous empirical evidence. Chapter 5 summarizes the main conclusions.

1.2. On farm conservation and the role of homegardens

Agro-biodiversity comprises three main levels: genetic diversity, species diversity and ecosystem diversity (CBD, 2010). Usually there are two complementary conservation strategies that refer to genetic diversity: ex situ and in situ. Ex situ conservation involves the collection of wild and crops species from their native habitat and then its storage off site as seeds in a gene bank, vegetative material in "in vitro storage", or plant accessions growing in botanical garden of field gene bank (Jarvis et al., 2000). In situ conservation means the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings (Maxted et al., 2002).

In the case of domesticated or cultivated species in situ conservation is also called on farm conservation, and it focus on the conservation of these domesticated plant or animal species, and also their wild relatives, in the surroundings where they have developed their distinctive properties, normally in traditional farming systems (Maxted et al., 2002). Bellon (1996) also defines on farm conservation as the continuous cultivation and management of a diverse set of populations by farmers in the agro-ecosystems where a crop has evolved.

The difference is that in situ conservation focus on species in their natural habitats, while on farm conservation can be a special category which focuses on domesticated crop species in their farming habitat where they have grown in time. Furthermore, on farm conservation strategies means that there is a decision making process by farmers about which variety or seed should retain each season, and thus how much diversity would they maintain.

The question is why to implement conservation strategies on farm. Jarvis (2000) outlined seven main benefits from on farm conservation of genetic diversity. First of all, conservation on farm will support the conservation not only for genetic diversity but also for ecosystem and species diversity. Second, it helps to ensure that the ongoing processes of evolution and adaptation of crops to their environments are maintained within farming systems. This means that on farm conservation is a dynamic solution versus a static ex situ conservation in which evolutionary and adaptative potential are more limited (Galluzzi et al., 2010). Third, farmers, who have the expertise and the traditional knowledge, would become important partners to implement the strategies. Fourth, ecosystems services would be preserved. Fifth, farmer's livelihoods would be improved by combining the conservation strategies with development activities. In this way, empowered farmers would also control and access the benefits of the genetic material maintained. Finally, everyone will benefit from the potential supply of genetic material, which is continuously evolving, for the future global food security, rather than only depend on the finite stock that gene banks keep.

However, on farm conservation has not being designed to replace current agricultural practices. The importance of on farm conservation does not mean that it is appropriate for every site and for every type of farmer. It implies the selection of specific areas and groups of farmers where on farm conservation practices could be more cost effective(Smale et al., 2004). The challenge is to integrate on farm conservation of agro-biodiversity with agricultural development (Brown, 1999).

As previously discussed, farmers have an important role in the conservation of agro-biodiversity. Selection is directed by farmers in response to local needs and conditions "domesticated plants have become dependent on the tiller's hand" (Brush 1999: p. 3). Genetic resources are renewed in farmers' fields only as long as farmers continue to sow the seed (Smale et al., 2004). They have developed such a strong knowledge about direct uses of the different varieties and certain agricultural practices. Farmers are considered crucial partners in the process of on farm conservation (Brown, 1999). One of its main goals is to encourage farmers to continue select and manage a diversity of species and varieties, their gene flow, and their traditional knowledge, while bringing them their direct benefits.

On farm conservation programs should target who are the group of farmers that are most likely to grow more species, which are their main characteristics, and where are located. This can reduce the costs of encouraging farmers' participation (Meng et al., 1998). On farm conservation activities bring together biological and social sciences. It involves the understanding of the dynamics of agro-diversity in farming systems by relating farmers' decision making and sustainable agricultural practices (Brown, 1999, Bellon, 1996).

Although on farm conservation is intended to preserve genetic diversity, in this paper, there will not be much distinction, because on farm conservation practices can also maintain diversity in the other two levels, species and ecosystems. In this context, this paper deals with on farm conservation of agro-biodiversity, in its three levels, in homegardens. Homegardens are one of the two traditional systems of low input farming in the humid tropics that have evolved under conditions of high population densities, together with wet rice cultivars (Hoogerbrugge and Fresco, 1993). Homegarden is an old tradition which still evolving for a very long time (Soemarwoto, 1987) and it seems a suitable alternative for the new challenges farmers are facing. In Indonesia first records of homegardens were found in the island of Java hundreds of years ago, there homegardens are very well developed and show a very high diversity of plants and animals per unit area (Soemarwoto and Conway, 1992). It is possible that it could become another option for farmers who: have to prevail low input farming, have a less negative impact from fertilizers, face diminishing areas of land and reduce their intensification levels (Hoogerbrugge and Fresco, 1993).

There is no unique definition of homegardens, since most of them may even vary significantly between each other. As it will be developed further in this paper, homegardens can be understood as farming systems or agro-ecosystems, on farm conservation strategies, livelihood strategies and in a way it can also be understood as an alternative technology for farmers. There are certain assumptions this paper follows about the main characteristics of homegardens found in the literature.

There is a consensus of understanding homegardens as land use systems involving multipurpose trees, shrubs and crops (as well as livestock) that are managed by family labor adjunct to the farmers houses (Kumar and Nair, 2004, Mohan et al., 2007, Kabir and Webb, 2008, Perfecto and Vandermeer, 2008, Aguilar-Støen et al., 2009, Huai and Hamilton, 2009).

Huai and Hamilton (2009) have listed the main functions of homegardens. First of all, homegardens provide households with a diversified production of food, fruits, vegetables, fodder, fuel, medicines and other materials for domestic use, and also with cash income. Second, ecologically, homegardens maintain soil fertility and nutrient cycling, ensures a more efficient use of resources and preserve important genetic resources. Third, homegardens are also useful as centers for the domestication of wild plants. Finally, homegardens may have high levels of cultural values to communities.

Homegardens relevance for conservation purposes resides in their capacity to represent agro-biodiversity at multiple levels over small spaces (Galluzzi et al., 2010). Several studies have concluded that diversity levels within homegardens are relatively high (Kabir and Webb, 2008, Aguilar-Støen et al., 2009). All these attributes and functions: low and efficient input requirement, diversification of production and minimization of income risk and enhanced food security, contribute to the sustainability of homegardens (Torquebiau, 1992, Kumar and Nair, 2004).

1.3. Research objectives and questions

Although homegardens exist for quite a long time, research about them is still limited. The objective of this paper is to contribute to the understanding of homegardens as a livelihood strategy from a farmer’s perspective and what are the main characteristics that explain the decision to undertake this strategy. This paper attempts to address the following main research question:

Which are the main economic factors influencing farmer's decisions about homegardens use?

Important subquestions are:

- Through a two stage econometric model which relates homegardens, as a livelihood strategy, and farmer`s livelihood assets, this paper will attempt to answer the following subquestion: what are the main interactions between homegardens and household assets, such as human capital, natural capital, physical capital?
- Are the institutional processes (access to infrastructure, land tenure, etc.) important variables that influence the ability to carry out homegardens strategies?
- Is there a specific pattern of livelihood asset holding that may increase the probability of homegardens use?
- Is there a significant difference in the results between the drivers that influence the probability of use and the extent of it?

The main hypothesis of this research is that there is a certain combination of livelihood assets that will influence significantly the decision of farmers to implement homegardens. By this, and through the model to be proposed, a better understanding about farmer's behavior towards highly diverse agricultural systems will contribute to a better target of on farm conservation practices.

In the following section a brief explanation of the theoretical frameworks will be developed. For this paper a sustainable livelihood approach will be used, and it will complemented by the literature of technology adoption. These approaches will improve the understanding of the main drivers that influence farmer's decision towards more sustainable practices, which are highly related to the activities in the farm and their effects on their livelihoods. Homegardens will be applied now, but in the future other types of on farm conservation activities could be also tested.

2. Theoretical Framework

2.1. Sustainable livelihood approach

The sustainable livelihood approach started to be discussed by development organizations around mid eighties and early nineties as a reaction of the failure of the conventional analysis of rural poverty. Other indicators of well being in rural areas were needed which not only focus on productivity, employment and cash income levels. A new way to understand the "plural priorities of the rural poor and their many and varied strategies to obtain a living" (Chambers and Conway 1992, p.3) was proposed under the sustainable livelihoods approach (Chambers and Conway, 1992, Farrington et al., 1999, Adato and Meinzen-Dick, 2003).

This approach is based on the relationship between three specific concepts: capability, equity and sustainability. Allison and Ellis (2001) also suggested that the concept of vulnerability is linked with this approach, defined as a high degree of exposure to risk, shocks and stress. This is tightly related with the first concept, capability, which refers to the ability to perform certain basic functions, including the capabilities of being able to cope with stress and shocks and being able to find and make use of livelihood opportunities. Equity refers to the equal distribution of assets, capabilities and opportunities. Sustainability, in environmental terms, connotes self sufficiency and long term self reliance when dealing with pollution, global warming, deforestation, overexploitation of resources and degradation. In social terms, sustainability focuses on the ability to maintain and improve livelihoods while maintaining the local and global assets and capabilities on which livelihood depend (Chambers and Conway, 1992).

Combining these concepts, the following definition of sustainable livelihoods has been proposed: a livelihood, which comprises the assets (natural, physical, human, financial and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household, is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, provide sustainable livelihood opportunities for the next generation, and when it contributes with net benefits to other livelihoods at the local and global levels in the short and long term (Chambers and Conway, 1992, Scoones, 1998, Allison and Ellis, 2001).

This framework involves a reduced form or a simplification of how livelihoods and its main components interact. However, the use of this framework is already implying a willingness to understand, in a more comprehensive way, the complexity of livelihoods (Adato and Meinzen-Dick, 2003). One of these components is the livelihood assets, which include the five types of capital well described in the literature: human capital, natural capital, financial capital, physical capital and social capital (DFID, 1999, Farrington et al., 1999). These assets are located within a context of vulnerability faced by the households and are influenced by the institutions, policies and social relations. After dealing with all these components, households determine their livelihood strategies, which are defined as the range and combination of activities and choices that people make in order to achieve their livelihood outcomes. This last component can go beyond just the maximization of income, and include improve food security or reduce their vulnerability (DFID, 1999).

In other words, given a particular context, which could include policy situations, historic backgrounds, agro-ecologic and socioeconomic conditions, the question to address is what is the combination of livelihood assets that results in the ability to implement what combination of livelihood strategies and with what outcomes? This paper will focus on farmer's ability to pursue a specific livelihood strategy, a homegarden system, and its dependency on the capital base of the household, which comprises material and social, tangible and intangible assets that farmers have in their possession (Scoones, 1998, Siegel, 2005).

A household's assets consist of the stock of resources used to generate well being (Alwang et al., 2005). Assets include human capital, natural capital, physical capital, financial assets, social capital (including also political and institutional assets) and location specific factors. The later has been suggested by the asset-based approach (which underlies, as the basics, the livelihood approach) as the proximity or distance of infrastructure that influences the availability and accessibility of goods and services (Siegel, 2005). The assets of a household are broadly defined to include the productive, social and location assets that, through the household's revealed behavior, determine the opportunity set of options for livelihood strategies (Siegel, 2005).

Rural livelihood strategies and their main determinants have been analyzed previously (Alwang et al., 2005, Jansen et al., 2006, van den Berg, 2010, Schuit, 2011). With different final objectives these studies have applied similar methodologies to understand the main relationships between household's portfolio of assets and their livelihood choices. Jansen et al. (2006), Schuit (2011) and van der Berg (2010), identified and quantified livelihood strategies through factor and cluster analysis to group farm households on the basis of the use of their labor and land resources, resulting in different categories of livelihood strategies depending on the main farm and off farm activities. Then, they analyzed how these strategies either influence well being outcomes or are affected by natural disasters. The main difference with previous empirical application of the sustainable livelihood approach is that in this paper only one livelihood strategy will be analyzed, namely, homegarden systems.

2.2. Technology adoption

The Green Revolution refers to a phenomenon in agricultural growth, which has included breeding of improved crop varieties, expanded use of fertilizers and other chemical inputs and irrigation development. These improvements have produced an increase in agricultural yields and farmer's income and hunger has been also reduced, especially in Asia and Latin America (Hazell, 2002).

The relevance of the technology adoption framework comes from an extensive theoretical and empirical literature which has focused on the effects of the Green Revolution. For instance, Feder, Just et al. (1985) reviewed different studies during early stages of the Green Revolution and then Feder and Umali (1993) did the same for mature innovations implemented in a later stage. A more recently review has been done by Foster and Rosenzweig (2010) to continue understanding the main determinants of technology adoption in a context of economic growth. Although in this paper homegardens cannot be considered as a "new technology" that farmers can adopt, this framework helps to identify important factors that might be influencing farmers' behavior to decide implement homegardens.

Farmers face different barriers and constraints affecting technology adoption processes. The adoption process can be defined as Rogers (1962) as "the mental process an individual passes from first hearing about an innovation to final adoption" (Feder, Just et al. 1985, p. 256). Final adoption at the level of the individual farmer is defined as the degree of use of a new technology in long run equilibrium when the farmer has full information of the potential of the new technology or farming practice (Feder et al., 1985). Models of adoption behavior of individual farms usually characterize the problem as one where the farmer has to choose between two options "adoption" versus "non adoption" or between two technologies "traditional" versus "modern" (Feder et al., 1985).

The theoretical framework to understand the adoption processes of farmers involves a model of decision making about the level of use of a new technology and a set of motion equations describing the parameters that affect the farmer's decisions over time. Among these equations we can consider changes as a result of a learning process or human capital differences and changes in the marketing network of associated inputs (Feder et al., 1985). At an early stage of adoption, the use of a new technology tends to be uneven and highly correlated with farmers and farm characteristics. Once the initial learning process has passed, differences in adoption are likely to be reduced (Brush et al., 1992). Most of the theoretical and empirical literature focuses on static analysis between the degree of adoption and key factors affecting it. The main factors investigated are farm size, land tenure, access to credit and insurance, human capital, labor availability, infrastructure, among others (Feder et al., 1985, Feder and Umali, 1993, Foster and Rosenzweig, 2010, Dethier and Effenberger, 2011).

In addition, there are different factors which determine whether a household can adopt or not certain strategies, such as homegardens (Ashley and LaFranchi, 1997). Between them we have livestock and off farm income, household size, composition, geography and the natural endowments, skills, among others (Ashley and LaFranchi, 1997, Scoones, 1998). It is possible to overlap this factors with the main categories of assets that households posses. Therefore, we can combine these different factors and link the sustainable livelihood approach with the literature of technology adoption to get a better understanding of the adoption process by farmers of homegardens (Adato and Meinzen-Dick, 2003).

Brush (1992) utilized a model to test the hypothesis that the adoption of improved potato varieties results in a displacement of local landraces reducing crop diversity on farms. A model of adoption was incorporated to explain the area with improved varieties (censored dependant variable). Farm size and distance to markets were found to be statistically significant suggesting a late stage of adoption of new varieties of potatoes by Andean farmers. This model will be follows to identify the key variables influencing farmer's decisions to implement and use homegardens. It is assumed in this paper that homegardens are already preserving higher levels of agro-biodiversity. However, this strong assumption can be relaxed and through further research it would be possible to address in addition how much biodiversity is maintained in homegardens compared to other farming systems.

Efforts to explain partial adoption on farms are most of the time based on risk considerations, and the different levels of risk aversion by farmers. Bellon and Taylor (1993) argued that agro-ecological factors play an important role in adoption of new technologies, and should be included. A model was utilized to test the effect of land quality differences on partial adoption of new technologies, such as high yield varieties. The model solutions depend on two main indicators: land quality heterogeneity and access to markets. The results showed that high yield varieties are more likely to be chosen in relatively better quality lands, and landraces are more likely to be adopted in lower quality lands. In addition factors enabling farmers to overcome credit and human capital constraints significantly influence planting decisions by farmers (Bellon and Taylor, 1993).

2.3. Conceptual model

There still an ongoing discussion about which specification would better describe farmer's decision behavior (Feder et al., 1985). Most of the times, implementation of agricultural practices is included as a dichotomous dependent variable (yes/no). However, there is much more information provided when the extent and the intensity of use are explained rather than only the initial decision or probability of use a practice. But, this continuous variable may also show singular characteristics, such as a lower bound of zero. Under these circumstances, Feder, Just et al. (1985) suggested that sufficient modeling detail might be attained in a two stage investigation, where first the probability of use is explained in a dichotomous choice model and then the extent of it, given that the practices is already implemented, could be explained in a conditional model with a continuous but limited dependent variable. These two stages are the result of a separate process, where first the individual decides whether or not to participate in the activity, and then by how much (Greene, 2012). For this research, a two stage model will be applied to first explain the probability of homegardens use by farmers (dichotomous yes/no use of homegardens), and then the main factors that explain the extent of homegardens (area used as homegarden) given that homegardens has been implemented.

Stage 1: $Prob(y_i = 0|w_i)$ (1)

Stage 2: $Prob\left(y_i = j\middle|x_i, w_{i,}y_i > 0\right)$ (2)

Equation (1) shows the first stage, denoting a binary probability model which determines whether a zero or a non zero outcome occurs. Equation (2) is the second stage which denotes a truncated model for the positive outcomes. Finally, w_i and x_i are a set of explanatory variables taken from the sustainable livelihood and technology adoption approaches. These two sets do not need to be the same in both equations (Greene, 2012). Function specifications will depend on the data.

3. Methodology

3.1. Data and research context

The Asian region is endowed with a high diversity of tropical fruits, between 300 and 500 species of tropical fruits occur in this region (Arora, 1997). Traditionally, tropical fruits are managed in a variety of production systems, such as natural forests, protected areas, buffer zones, homegardens and semi commercial and commercial orchards.

This paper was developed as a result of the author's participation in the ongoing UNEP/GEF project entitled "Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting Sustainable Livelihoods, Food Security and Ecosystem Services" coordinated by Bioversity International among other government institutions. The project is being implemented in four different countries in South and Southeast Asia: India, Indonesia, Malaysia and Thailand; and it focuses in four different species of tropical tree fruits: mango, citrus, rambutan and mangosteen. These four countries are located in the centers of diversity of these fruit species (Verheij et al., 1991). The major criteria used for the selection of species were:

- Presence of associated biodiversity or wild relatives
- Importance to rural livelihoods and national economy
- Uniqueness to local socio-cultural and consumer preferences
- Comparative advantage in terms of potential for development, local knowledge (formal and informal)
- Markets (local and global), nutritional value and health, with multiple uses including culture/religious uses and post-harvest processing/transport/handling
- Contribution to ecosystem functions
- High national priority
- Genetic diversity of the cultivated and wild species is threatened

For the purpose of this paper, and after evaluating the quality of the data collected, the analysis focused on Indonesia. Indonesian agriculture consists of many smallholders, especially for tree crops and is between the top ten countries that produce oranges, mangoes and tropical fresh fruits (FAO, 2012). Indonesia is located in the center of diversity for the fruit species targeted in the project (Verheij et al., 1991). Traditionally in Indonesia, a significant proportion of each household's food is derived from the homegarden or *pekarangan*, which its production is far more diverse and versatile and appears to be inherently more stable and sustainable than other important land uses such as rice fields (Soemarwoto and Conway, 1992).

The project started by selecting the sites. The main criteria to select the sites were: high inter and intra specific diversity, availability of diverse agroecological systems (forests, homegardens, orchards) and importance of selected tropical fruits for households. Therefore, the analysis of homegardens was undertaken among households that have adopted different farming systems, allowing a comparative analysis between homegardens and the rest. In Indonesia six sites were included in the project and are part of the analysis of this paper: two located in East Java (Kediri and Magetan) and four located in South Kalimantan (Telaga Langsat, Sei Tabuk, Cerbon and Astambul).

After sites were selected, a baseline survey was implemented between November and December of 2011, through a structured questionnaire at a household level. Through this questionnaire the main indicators of diversity and socioeconomic factors were collected. The questionnaire included the following modules:

- Household characteristics and composition
- Fruit diversity on farm (orchads, homegardens and natural forests)
- Farm characteristics (farming systems and welfare indicators)
- Sources of income (tropical fruits, other farm income and off farm income)
- Access to markets and social networks
- Perceptions and good practices

A sample was identified to carry out the questionnaire. For its representativeness, a random sampling method was applied to the population of households per community with tropical fruit trees. A lower bound was established with a minimum of 50 households per community. The total number of Indonesian households interviewed was 358[1].

3.2. Dependent and explanatory variables

The dependent variable, area of homegardens in hectares, presents particular features. From a total number of 349 valid observations, farmers have on average 0.11 hectares of homegarden (see Table 1), and the variance is relatively small 0.067. A proportion of 18% observations present zero values, and the largest homegarden area is 2.5 hectares. Graph 3 shows the histogram for this variable, which shows a strong left skewness of the distribution. As it will be discussed in the next section, the area of homergardens is considered a censored dependent variable, and this feature should be taken into account in the regression analysis.

[1]The project objectives and time constraints might have produced sample selection in the data.

Graph 3 Homegarden area histogram

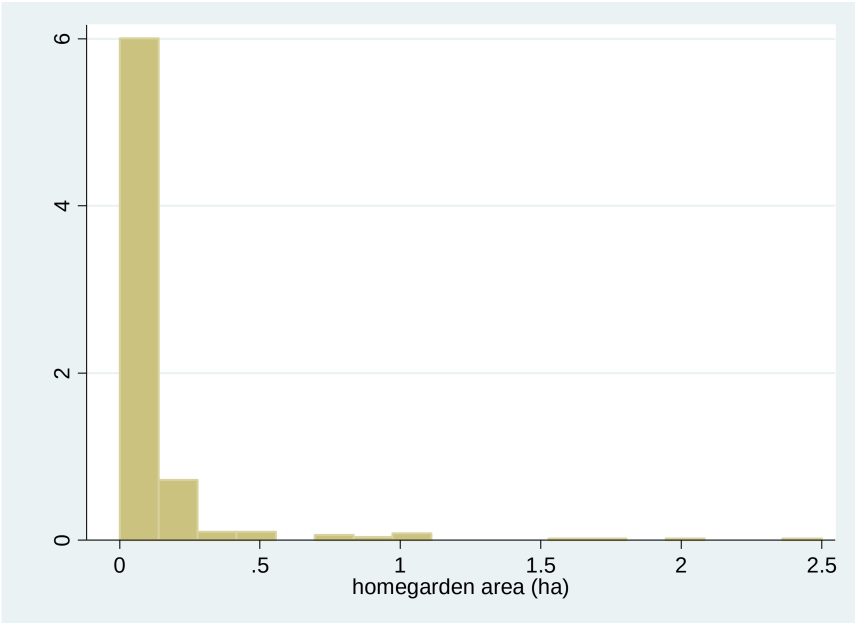


Table 1 Main characteristics of homegarden area

Observations	349
Mean	0.107
Std. Dev.	0.256
Variance	0.066
Skewness	5.592

The explanatory variables considered are mainly farmer's livelihood assets and other key factors that are used to explain farmer's adoption of new technologies. The variables to be included in the model are defined in Table 2. Human, natural and location capital are relatively fixed and stable over time, therefore are considered predetermined variables. Some awareness should be taken into account because the rest of the variables could present some symptoms of endogeneity, either for being less deterministic than the first ones and influenced by other variables, or for the chance of being understood more than outcomes rather than causes, such as livestock or off farm income. For those variables endogeneity tests cannot be performed because of data restrictions[2]. In addition, this paper will also understand institutional effects over the use of homegardens, reflected among these variables, which in some extent are out of the control of the farmers. Finally, complementarities between assets are also important. Certain assets are significant only if combined with others (Siegel, 2005) this is why some interaction effects would be also tested.

[2] Information was not available to include instrumental variables.

Table 2 Explanatory variables for the homegarden decision model

Variables	Description
human capital	
family size	Number of household members
gender	Gender of household head (1 = female, 0 = male)
age	Age of household head (years)
education	Literacy of household head (1 = yes, 0 = no)
dependecy	Proportion of dependent members in the household
female	Proportion of female members in the household
natural capital	
farm size	Total area of farmland operated by the household[3]
land quality	Land quality at least good (1 = yes, 0 = no)[4]
physical capital	
livestock	Possession of cows (1 = yes, 0 = no)
off farm income	Off farm income (1 = yes, 0 = no)
location capital	
number markets	Number of market channels used by household
distance market	Time distance to the closest market (hours)
site location	Dummies to control for the location of each of the six sites
financial capital	
credit access	Access to credit in the last 5 years (1=yes, 0=no)
land tenure	Property is owned by farmer (1=yes, 0=no)
social capital	
membership	Member of a community organization (1=yes, 0=no)

Table 3 Main characteristics of the explanatory variables

Variable	Obs	Mean	Std. Dev.	Min	Max
family size	358	3.992	1.585	1	11
gender	356	0.090	0.286	0	1
age	356	50.435	13.389	24	85
education	356	0.907	0.290	0	1
dependecy	358	0.395	0.257	0	1
female	356	0.479	0.174	0	1
farm size	340	0.819	0.865	0.02	6.594
land quality	348	0.181	0.386	0	1
land tenure	346	0.939	0.239	0	1
livestock	356	0.129	0.336	0	1
off farm income	358	0.598	0.491	0	1
number markets	358	0.950	0.505	0	3
distance market	325	0.162	0.386	0	3
credit access	358	0.209	0.408	0	1

[33] A logarithm transformation will be applied to this variable for normality purposes.
[4] This variable has been constructed from a categorical variable including: good, better than average, average, poorer than average and poor of the whole farm, which is not free of involving a subjective perception of the farmer.

membership	358	0.645	0.479	0	1

In table 3 the main characteristics of the explanatory variables are presented. Although the dependent variable comprises 349 valid observations, the number of households interviewed in the Indonesian sites summed up 358, the difference refers to missing values of the area of homegardens, mainly outliers that were dropped out of the sample. Most of the variables present complete information, only distance to markets and farm size show a relatively significant number of missing data. On average, the number of family members is four, with a head of the household with 50 years, relatively well educated, and more likely to be male. Over a third of the family members are considered dependent on the head, and half of them are women. The size of the farm is on average less than one hectare. Land quality is perceived on average not so good, and most of the farmers own their farm land. A small proportion of the farmers possess livestock, and more than half earn and additional off farm income. Although on average the distance to markets are relatively small, farmers on average use less than one market channel. Zero values of distance can suggest no use of markets. Access to credit is relatively modest and more than half of the farmers on average are members of a community organization, mainly farmers' groups or for religious purposes. All these characteristics reflect a standard semi commercial farm household which works on relatively small farms, produces mainly for subsistence and the remaining for commercial purposes, through its transaction in imperfect markets.

Before the estimation, multicollinearity between the regressors was analyzed (see Table 4). As a result there is no much problem between them, only land tenure was not included in the first stage after being dropped by STATA. Finally, heteroskedasticity might be a problem for both stages, this will be tested after the estimations and if the problem is present a robust standard errors will be used.

Table 4 Correlation matrix for the explanatory variables

	family size	gender	age	educa-tion	depen-dency	female	ln(farm size)	land quality	land tenure	livestock	off farm income	number markets	distance market	credit access	member-ship
family size	1														
gender	-0.188	1													
age	-0.089	0.109	1												
education	-0.034	-0.125	-0.126	1											
dependecy	0.438	-0.129	-0.319	0.065	1										
female	-0.111	0.372	0.032	0.017	-0.038	1									
ln(farm size)	0.104	-0.120	-0.166	0.040	0.015	-0.004	1								
land quality	-0.041	0.022	-0.137	0.063	0.063	-0.050	0.016	1							
land tenure	-0.028	-0.078	-0.015	-0.023	-0.040	-0.039	-0.058	0.029	1						
livestock	0.040	-0.032	0.034	-0.141	-0.039	-0.018	-0.033	-0.058	0.048	1					
off farm income	0.137	-0.004	-0.059	-0.083	0.125	0.064	-0.151	-0.059	-0.115	0.019	1				
number markets	0.157	-0.084	-0.066	-0.196	0.134	0.043	0.013	-0.008	0.009	0.220	0.183	1			
distance market	0.221	0.076	-0.095	-0.044	0.071	-0.002	0.029	-0.054	-0.017	0.111	0.128	0.257	1		
credit access	-0.029	0.070	0.012	-0.021	-0.050	0.090	-0.103	0.047	-0.062	0.002	0.107	0.135	-0.074	1	
membership	0.078	-0.101	-0.009	0.016	0.016	-0.015	0.069	0.030	-0.018	0.058	0.039	0.041	-0.024	0.103	1

3.3. Corner solutions and two stage hurdle model

The area of homegardens considers only positive continuous observations, thus it is censored at zero. Taking ordinary least squares (OLS) will derive to inconsistent estimators when using the full sample and also when using only the positive observations. Censored regression models generally apply when the variable to be explained is partly continuous but has positive probability mass at one or more points (Wooldridge, 2002). It is important to keep in mind that this model applies to conceptually different problems.

The most known application of the censored regression model occurs when the variable of interest is not observable for part of the population. The difference with truncation models is that in the former information on the dependent variable is lost, but not are the data on regressors, while in the truncation models, both information from the dependent and regressors are lost.

Another application is related with a corner solution outcome. This outcome can take zero values with positive probability but is a continuous random variable over strictly positive values (Wooldridge, 2002). This occurs for example when for a large proportion of the sample the outcome is the corner solution y=0. For corner solutions, the issue is not data observability, instead is the interest in features of the distribution of y given x, such as $E(y|x)$ and $Pr(y=0|x)$. This application is more suitable to explain the area of homegardens.

The starting point to analyze this type of data is tobit I model or standard censored tobit model. In corner solution applications, an important limitation of the standard tobit model is that a single mechanism determines the choice between y=0 versus y>0 and the amount of y given y>0. Alternative models have been suggested to allow the initial decision of y>0 versus y=0 to be separate from the decision of how much y given that y>0. These are often called hurdle models or two-tiered models.

Previously, the conceptual model was described in section 2.3 and it suggested a two stage model as the best alternative to explain the different processes regarding the use of homegarden systems. Therefore a hurdle model was chosen. For example, to use a homegarden , different assets may differently affect the decision to use a homegarden at all and the decision on how much area to use. This model will overcome the non linearity problem and the high presence of zero values, which must have a special treatment. Therefore two dependant variables would be used. For the first stage, a dummy variable for homegardens implementation yes or no was estimated using a logit model. For the second stage a logarithm transformation of the area of homegardens was used and it was estimated using ordinary least squares (OLS). The results can be compared with the standard tobit.

4. Results and Discussion

The final model was specified by the equations (3) and (4):

1 stage: (3)

$$Prob(y_i = 0|w_i) = \alpha + \beta_1 family\ size + \beta_2 gender + \beta_3 age + \beta_4 education + \beta_5 dependency + \beta_6 female + \beta_7 \ln(farm\ size) + \beta_8 land\ quality + \beta_9 livestock + \beta_{10} off\ farm\ income + \beta_{11} n^{\underline{o}}\ markets + \beta_{12} distance + \beta_{13} distance^2 + \beta_{14} credit + \beta_{15} membership + \beta_{16} \ln(farm\ size) * education + \beta_{17} site\ Astambul + \beta_{18} site\ Cerbon + \beta_{19} site\ Kediri + \beta_{20} site\ Magetan + \beta_{21} site\ Sei\ Tabuk + u_i$$

2 stage: (4)

$$Ln(y_i|x_i, w_i, y_i > 0) = \delta + \gamma_1 family\ size + \gamma_2 gender + \gamma_3 age + \gamma_4 education + \gamma_5 dependency + \gamma_6 female + \gamma_7 \ln(farm\ size) + \gamma_8 land\ quality + \gamma_9 land\ tenure + \gamma_{10} cows + \gamma_{11} off\ farm\ income + \gamma_{12} n^{\underline{o}}\ markets + \gamma_{13} distance + \gamma_{14} credit + \gamma_{15} membership + \gamma_{16} site\ Astambul + \gamma_{17} site\ Cerbon + \gamma_{18} site\ Kediri + \gamma_{19} site\ Magetan + \gamma_{20} site\ Sei\ Tabuk + e_i$$

The results of the two stage model of homegardens use are shown in Table 5. The valid number of observations with the complete information required was reduced to 301 households for the first stage and 245 for the second[5]. After performing the regression explained previously here we can analyze its results in detail. First of all, interaction effects were not found largely significant, only ln(farm size)*education has a significant and positive effect over the probability to adopt a homegarden. The results show that the factors explaining the probability of homegarden implementation differs from the factors explaining the extent of the use.

For the first stage, the significant factors which determine the probability of homegarden implementation[6] in Indonesian sites were education of the household head, the size of the farm (in logarithm), both variables interacting, and being located in Kediri. Households with a better educated head will increase the probability of homegarden use. After calculating the marginal effects, if the head of the household becomes literate the probability that farmers are implementing homegardens will increase in 0.25. Moreover, if farm size increases in 1% the probability will be reduced in 0.0008%, but if both variables interacts, well educated head of households working in larger farms, will increase the probability. Finally, being located in Kediri will significantly decrease the probability of homegarden implementation in 0.79.

After the homegarden system is already implemented, the main factors influencing the extent of it are the size of the family or availability of labor, and the size of farm or availability of land, both in a positive and significant way. Production inputs availability is an important and in a way immediate driver, this is related with the costs of homegarden use. An additional member in the family will increase the area of homegardens in 10,6%, while 1% increase in the size of the farm will increase in 0,40% the area of homegardens. Moreover, locational capital

[5] Because of missing data from the explanatory variables.

[6] This model explains why farmers have not implemented homegardens as shown with the probability of y=0. By default the logit model will run the probability of success when the variable is equal to one. We have to consider the marginal effects but with the opposite sign.

variables are found significant as well, between them distance to markets, and being located in Magetan and Sei Tabuk. The distance to markets affects the extent of use of homegardens significantly but in a negative way. One additional hour away from the market will reduce the size of homegarden by almost 60%. If the farm is located in Magetan site will affect in a positive way the area selected for homegardens, if the farm is in Sei Tabuk, the effect will be negative.

For comparison, the results using a standard tobit model censored at zero is also shown in Table 5. In spite of the high pseudo R-squared, the individual effects of each explanatory variable are not captured by the tobit model. This suggests that assuming the same decision making process for homegardens use at all, and for the extent of it given that the homegarden is implemented, with a standard tobit is in fact cancelling out each other effects, or not capturing these effects at all.

From a livelihood approach, human capital, represented by family size and education; natural capital, represented by the size of the farm, and locational capital, represented by distance to markets and the location of the sites, are the main livelihood assets that determine farmers' decision to include homegardens as a livelihood strategy. It is interesting to see that the assets that are more significant are the more stable or deterministic. This suggests that assets that can be considered endowments are the basis for homegarden use.

A common finding in the adoption literature is that more educated farmers are more likely to adopt new technologies (Foster and Rosenzweig, 2010). There are three mechanisms that have been hypothesized in the literature to explain this link. First, more educated farmers are wealthier, and thus this link represents an income effect. However, the analysis is controlling for wealth (livestock) and off farm income. Second, more educated farmers have better access to information. Third, more educated farmers are better able to learn. Last two reasons are more convenient to understand the relationship.

Farm size is one of the first factors on which the empirical adoption literature is focused (Feder et al., 1985). However, the variety of results that have been presented in the literature suggests that underlying effects can be affecting the relationship between farm size and adoption. The results for homegardens suggest that farm size decreases the probability of its use. This is related with the costs of implementation, the larger the farm size, more commercial activities could be prioritize where fixed costs can be spread out, instead of homegardens, which normally are developed in small plots. However, if the homegarden is already adopted, as farm size increases homegarden size will also tend to increase.

Institutional processes play a role in the use of homegardens by farmers, although credit access was not significant in the final model, access to markets and indirectly, infrastructure services resulted highly significant in the second stage. In the first stage, only distance to market squared was found significant. These results suggest that if farmers have less access to markets, more hours to the market, they will increase the probability that a homegarden is plemented (positive but not significant), but the area of homegarden systems will not be too extensive (negative and significant).

Any technology that entails paying upfront costs requires that the agent have funds available prior to the realization of the gains from adopting the technology (Foster and Rosenzweig, 2010). The non significance of credit access, and even farmers' characteristics, suggests that agents may have the funds to afford the strategy. As it has been described, homegardens is not an expensive system that actually requires few inputs. Results highlight labor and land.

Indonesian farmers have a long tradition of homergardens, the results show that their learning process regarding homegardens use, influenced by their own experience, is in a late stage (experience represented by age was not found significant). Only education is affecting this strategy by facilitating the capacity of farmers to receive information from the experience of other farmers. Tropical fruit farmers are already experienced in the use of homegarden systems in their activities. This leads to conclude that these tropical fruits were not included recently in the homegardens of the sites selected in this analysis. As Indonesia is center of diversity, these species have been evolving quite a long time in this traditional system.

Table 5 Results of the homegardens hurdle model

	(1 stage) Probit homegarden dummy	(2 stage) ols ln(homegarden area)	(for comparison) tobit homegarden area
family size	0.035	0.106*	-0.003
	(0.136)	(0.049)	(0.016)
gender	-0.756	0.351	0.002
	(0.691)	(0.253)	(0.031)
age	-0.006	0.003	0.001
	(0.015)	(0.005)	(0.001)
education	2.122**	-0.250	0.076
	(0.793)	(0.273)	(0.116)
dependency	-0.152	-0.022	0.068
	(0.723)	(0.302)	(0.069)
female	0.289	-0.120	0.031
	(1.733)	(0.411)	(0.069)
ln(farm size)	-1.424*	0.407***	0.011
	(0.700)	(0.075)	(0.081)
land quality	-0.413	0.198	0.062
	(0.778)	(0.170)	(0.042)
land tenure		0.115	-0.040
		(0.277)	(0.031)
livestock	1.052	-0.304	0.059
	(0.537)	(0.239)	(0.059)
off farm income	-0.318	0.089	0.020
	(0.539)	(0.150)	(0.034)
number markets	-0.645	-0.039	-0.033
	(0.428)	(0.167)	(0.023)
distance market	2.149	-0.588*	-0.008
	(1.377)	(0.244)	(0.067)
distance markets squared	-1.818*		-0.017
	(0.757)		(0.030)
credit access	0.833	-0.023	-0.017
	(0.601)	(0.167)	(0.031)
membership	-0.218	-0.137	-0.038
	(0.476)	(0.140)	(0.026)
farm size*education	1.643*		0.080
	(0.799)		(0.093)
site astambul	-2.339	0.184	0.008
	(1.236)	(0.243)	(0.032)
site cerbon	-0.650	0.276	0.071
	(1.791)	(0.291)	(0.076)
site kediri	-5.082***	0.296	-0.163**
	(1.224)	(0.353)	(0.058)
site magetan	-1.336	1.490***	0.219**
	(1.237)	(0.252)	(0.068)
site seitabuk	0.776	-0.512*	-0.037
	(1.693)	(0.215)	(0.030)
intercept	3.030	-3.315***	0.021
	(2.282)	(0.611)	(0.144)
sigma			0.224***
			(0.045)
nº observations	301	245	292
R-squared		0.380	
pseudo R-squared	0.473		0.866
log likelihood at intercept	-133.725		-55.069
log likelihood full model	-70.503		-7.377
chi-squared test	78.429		
F test		6.867	1.95
p-value	0.000	0.000	0.008

Coefficients of the estimators, Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5. Conclusions

Climate change and food security are considered major challenges for humankind. Agriculture plays a key role in both challenges. Agro-biodiversity provides the food necessary to feed the growing population, and the ecosystem services necessary to maintain a resilient agro-ecosystem. However, current agricultural practices are threatening agro-biodiversity and its functions by replacing natural ecosystems with intensive farming systems. This kind of agricultural practices has caused a significant simplification and homogenization of agro-ecosystems which are relatively more unstable and vulnerable to diseases and pests. This is why conservation of agro-biodiversity is of vital importance.

This paper deals with on farm conservation of agro-biodiversity in homegardens in Indonesia. Homegardens are one of the two traditional systems of low input farming in the humid tropics that have evolved under conditions of high population densities. Homegarden are considered traditional systems that can be included in on farm conservation programs. The objective of this paper was to understand the behavior of farmers towards more sustainable agricultural practices, specifically to identify if there is a combination of factors that influence the way farmers include homegardens as an additional livelihood strategy.

Indonesian homegardens is considered an old traditional farming system. In addition, Indonesia has suffered both positive and negative effects of the Green Revolution. Moreover, is considered center of diversity of tropical fruits. All these features anticipate Indonesian interesting results of the analysis of homegarden use.

The main results suggest that farmer's education, amount of available land, their interacting effect, and being located in Kediri site are the main economic factors influencing the probability that homegardens are being implemented. Moreover, labor and land availability, distance to markets and being located in Magetan are the main factors that determines homegardens extension. From a livelihood perspective, the main livelihood assets that influence homegarden livelihood strategy are the human, natural and locational assets. Livelihood assets that can be considered endowments determine the implementation of sustainable practices, such as homegardens. Policy makers should guarantee a minimal provision and distribution of basic endowments, such education, land and infrastructure, while implementing on farm conservation practices. This is why on farm conservation and rural development programs should be integrated.

The fact that fruit farmers' characteristics were not found significant, especially farmers' experience, implies a late stage in the homegarden learning process. Within tropical fruit cultivations, policies and activities that will improve education levels in the community will increase the probability and extent of homegarden use. Market access could increase the extension of the homegarden but would decrease the probability of adopting it in the first place.

One drawback of the results is that it might be quite specific for the giving context, Indonesian fruit farmers adopting homegardens. The results are reliable within the data and sites analyzed, however the results can vary depending on the technology, the level of diversity, among others. What is important to remark is the methodology and its usefulness to identify the main characteristics of the farmers and their assets, so targeting on farm conservation programs would be more cost effective.

Farmers play a key role by providing and managing agro-biodiversity. They are considered crucial partners when sustainable practices are developed. Understanding the factors that determine farmer's decisions to apply more sustainable practices, such as homegardens systems, is important to improve policy making and on farm conservation activities which preserve the benefits of agro-biodiversity. Therefore policies that strengthen simultaneously both rural livelihoods of small farmers and on farm conservation practices, through for instance homegarden systems, should be encouraged.

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