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Abstract

One of the main causes of tropical forest loss is conversion to agriculture, which is constantly increasing as a dominant land cover in the tropics. The loss of forests greatly affects biodiversity and ecosystem services. This paper assesses the economic return from increasing tree cover in agricultural landscapes in two tropical locations, West Java, Indonesia and eastern Bangladesh. Agroforestry systems are compared with subsistence seasonal food-crop-based agricultural systems. Data were collected through rapid rural appraisal, field observation, focus groups and semi-structured interviews of farm households. The inclusion of agroforestry tree crops in seasonal agriculture improved the systems' overall economic performance (net present value), even when it reduced understorey crop production. However, seasonal agriculture has higher income per unit of land area used for crop cultivation compared with the tree establishment and development phase of agroforestry farms. Thus, there is a trade-off between short-term loss of agricultural income and longer-term economic gain from planting trees in farmland. For resource-poor farmers to implement this change, institutional support is needed to improve their knowledge and skills with this unfamiliar form of land management, sufficient capital for the initial investment, and an increase in the security of land tenure.

Keywords: deforestation, crop production, tree planting, income, ecosystem service

Introduction

Throughout the past century, tropical forests have declined mainly due to land conversion (Laurance, 2007; Lambin et al., 2003), and continue to be lost at alarming rates (Davidar et al., 2010). Although recent conservation efforts may have slowed down the speed of deforestation, every year the area of tropical forest decreases by an estimated 12.3 million ha (FAO, 2010)[1]. With an estimated two billion extra people expected on the planet in the next 25 years, primarily in tropical areas, forests and their biodiversity face an increasingly uncertain future (Beenhouwer et al., 2013). Although the underlying causes and the drivers of agents' forest clearing behaviour are complex (Babigumira et al., 2014), it is widely found that one of the main immediate causes of forest conversion in the tropics is to provide land for subsistence or commercial agriculture (Babigumira et al., 2014; Hosonuma et al., 2012; Hersperger et al., 2010; Angelsen and Kaimowitz, 1999). Furthermore, with the scale and impact of agriculture constantly rising, and emerging as a dominant land cover in the tropics, forest biodiversity and ecosystem services will be increasingly affected by the agricultural landscape matrix (Perfecto and Vandermeer, 2008; Scherr and McNeely, 2008).

Food production and biodiversity conservation are not necessarily mutually exclusive, and there is no simple relationship between the biodiversity and crop yield of an area of farmed land (Beenhouwer et al., 2013). Rural land use challenges in the tropics also include environmental degradation on fragile agricultural lands (Rahman and Rahman, 2011), including a decrease in soil fertility experienced by farmers (Snelder and Lasco, 2008). Evidence from a number of studies indicates declining growth of yields under intensive cropping even on some of the better lands, e.g. the Indo-Gangetic plains (Vira et al., 2015; FAO, 2011; ILEIA, 2000). In response, tropical agroforestry systems have been proposed as a mechanism for sustaining both biodiversity and its associated ecosystem services in food production areas (Steffan-Dewenter et al., 2007; Schroth et al., 2004), by increasing tree cover, while maintaining food production. The importance of agroforestry systems in generating ecosystem services such as enhanced food production, carbon sequestration, watershed functions (stabilization of stream flow, minimization of sediment load) and soil protection is being increasingly recognized (Lasco et al., 2014; Idol et al. 2011; Jose, 2009; Roshetko et al., 2007a; Alavalapati et al., 2004; Schaik and van Noordwijk, 2002). Tree components also produce important products, e.g. wood, fruits, latex, resins etc., that provide extra income to farmers and help alleviate poverty (Tscharntke et

[1] In Asia a recent net increase in forest cover has been reported at the regional level due to large-scale successful afforestation efforts in China, India, Viet Nam, and Thailand. However, these 'planted forests' are inferior for providing the full range of ecosystem services (Roshetko, 2013; Xu, 2011).

al., 2011; Snelder and Lasco, 2008; McNeely and Schroth, 2006). The economic return, especially net present value (NPV), internal rate of return (IRR), benefit-cost ratio (B/C), return-to-land and return-to-labor of agroforestry has been found to be much higher than from seasonal agricultural systems in many locations (Roshetko et al., 2013; Rahman et al., 2008; Rahman et al., 2007; Rasul and Thapa, 2006; Alavalapati and Mercer, 2004; Elevitch and Wilkinson, 2000). This is especially so for marginal farmlands where agricultural crop production is no longer biophysically or economically viable (Roshetko et al., 2008), and may become incompatible with the sustainable development concept with its major focus on 'people-centered' development (Snelder and Lasco, 2008).

Many ecological and economic studies have been conducted on the effect of land-use change, and management at the landscape scale, on ecosystem services (e.g. Grossman, 2015; Labriere et al., 2015; Ango et al., 2014; Baral et al., 2014; Vaast and Somarriba, 2014; Jose, 2009; Steffan-Dewenter, 2007). However, only a few (Wood et al., 2016; Sinare and Gordon, 2015; Tremblay et al., 2015) have focused on the simultaneous delivery of different agro-ecosystem services (including especially the maintenance of food provisioning) under scenarios of increasing tree planting in smallholder land use systems, and none of these carried out their research in Asia (see also Snelder and Lasco, 2008). Thus, this study seeks to fill this gap by assessing the trade-offs between income and tree cover when incorporating trees into food-crop-based agricultural systems in two tropical Asian locations, West Java, Indonesia and eastern Bangladesh. Our analysis compares provisioning ecosystem services provided by agroforestry with seasonal food crop farming, practiced in either swidden or permanent systems. Expansion of these subsistence systems is a major contributing factor to forest loss and environmental degradation in West Java (EST, 2015; Galudra et al., 2008). Similarly, upland slash-and-burn swidden agriculture, which is the dominant economic land use (Rahman et al., 2014), is a leading cause of deforestation in eastern Bangladesh. Hence, the two locations represent a complementary pair of examples for our analysis targeting the effect of increasing tree cultivation, and thus tree cover, in the dominant[2] type of Asian tropical agricultural landscapes.

This study will provide new information on the contribution that can be made to the income of seasonal food crop farmers by adopting agroforestry practices, specifically through production of a wider range of food and timber provisioning ecosystem services. It will meet the need for more detailed research resulting in quantitative data from different locations on a range of agroforestry systems compared

[2] In the tropical rural Asian landscapes, agriculture is the dominant type of economic land use (Babigumira et al., 2014).

with alternative farming practices, which is crucial evidence to better inform land use and farming policy and development practice (Snelder and Lasco, 2008; FAO 2006).

Materials and methods

Study site

This research was conducted in Gunung Salak valley, Bogor District, West Java, Indonesia and Khagrachhari district, eastern Bangladesh.

The research site in Indonesia lies between 6º 32' 11.31'' S and 6º 40' 08.94'' S latitudes and between 106º 46' 12.04'' E and 106º 47' 27.42'' E longitudes. The climate is equatorial with two distinct seasons[3], i.e. relatively dry (April-October) and rainy (November-March). The region is more humid and rainy than most parts of West Java. Given the proximity of large active volcanoes, the area is considered highly seismic (Badan Pusat Statistik, 2013; Wiharto et al., 2008) leading to highly fertile volcanic soils (Table 1.1). Field data were collected from three purposively selected[4] sample villages: Kp. Cangkrang, Sukaluyu and Tamansari, which are located in the northern Gunung Salak valley. The latter two villages contain a mixture of households practicing each of the two land use systems that form the major comparison of this study: subsistence seasonal swidden farming and agroforestry. The first village is located in a different part of the watershed, most of its studied households carry out a different farming system (permanent monoculture farming) and it is included in this study as an outgroup comparison. The total population in this area is approximately 10,200 people spread across 1600 households. Villages have poor infrastructure, and household incomes are mainly based on agricultural and forest products, sold in local and district markets, in addition to wage labor and retailing (Badan Pusat Statistik, 2013).

The research site in Bangladesh is part of the Chittangong Hill Tracts, the only extensive forested hilly area in Bangladesh, which lies in the eastern part of the country between 21º 11' 55.27'' N and 23º 41' 32.47'' N latitudes and between 91º 51' 53.64'' E and 92º 40' 31.77'' E longitudes. The area has three distinct seasons, i.e. hot and humid summer (March–June), cool and rainy monsoon (June-October) and cool and dry winter (October-March) (BBS, 2014). Mean annual rainfall is higher than the Indonesian study site, and soils were also highly fertile (Table 1.1). Field data were collected from two

[3] In the Indonesian study site rainfall occurs throughout the year, but based on its intensity two seasons are recognized, with heavy rainfall demarcating the rainy season.

[4] The villages were selected based on stratification by watershed location and having the largest sample size of farm households that practice its associated land use system, i.e. in the lower watershed permanent monoculture (Kp. Cangkrang), and in the middle (Sukaluyu) and upper (Tamansari) watershed swidden and agroforestry.

purposively selected sample villages[5], Mai Twi Para and Chondro Keron Karbari Para, with a total population of approximately 750, in 135 households. These two villages have poor infrastructure, and household incomes are mainly based on the sale of agricultural and forest products in local and district markets, with wage labor providing additional household income. They both include a mixture of households practicing each of the two land use systems that form the major comparison of this study: subsistence seasonal swidden farming and agroforestry.

In both research sites, agriculture is mainly a subsistence practice, conducted by small-scale farmers and deeply rooted in their culture. The main agricultural crops (upland rice, paddy rice, and a diversity of vegetables and fruit) are mainly cultivated in agricultural fields year-round. In all the studied villages, forest products (FPs) are collected from nearby forests. Farmers practicing swidden prepare new areas of land using the traditional slash-and-burn method to cultivate predominantly the food crops upland rice, maize and vegetables. They rotate crop cultivation between fields to maintain soil fertility by leaving land fallow for 2-4 years. Farmers practicing permanent monoculture agriculture in the Indonesian site grow single seasonal crops (predominantly upland rice, paddy rice, maize, vegetables or spices). Some farmers have replaced such traditional crops with high-value cash crops, e.g. taro, banana and papaya. In both research sites, some farmers have adopted a range of agroforestry systems (e.g. fruit tree, timber tree or mixed fruit-timber), where trees are grown together with seasonal and perennial crops.

Table 1.1: Basic characteristics of the research sites.

Characteristics	**Indonesia**	**Bangladesh**
Average precipitation (mm/year)	1700	2540
Average relative humidity (%)	70	66
Average temperature (˚C)	26	24
Soil	Highly fertile derived from volcanic and sedimentary rocks	Highly fertile of variable depth above broken shale or sandstone as well as mottled sand
Main economic activities	Agricultural and forest products, wage labor and retailing	Agricultural and forest products, wage labor
Main source of forest products	Natural forest	Natural and secondary forest
Forest products collected	Firewood, rattan, bamboo, fruits, vegetables	Firewood, timber, bamboo, rattan, wild fruits, vegetables

[5] The area consists of hills, and the two villages were selected as those with the largest sample size of farm households that practice the farming systems being compared in this study, i.e. swidden and agroforestry.

Agricultural markets	Village and district	Village and district
Local land use	Household dwelling units, home gardens, agricultural fields and forests	Household dwelling units, home gardens, agricultural fields and forests
Land tenure	State *de jure* owner. Private and community *de facto* user[6].	State *de jure* owner. Private and community *de facto* user[7].

Data source: BBS, 2014; BBS, 2013; Badan Pusat Statistik, 2013; Wiharto et al., 2008; Local Agricultural Office; RRA and village survey in this study.

Data Collection

Primary data of the basic socioeconomic and geographical state of the research sites were collected by rapid rural appraisals (RRA) using village mapping and key informant interviews (FAO, 2015; Angelsen et al., 2011). Key informant interviews and village mapping sessions were conducted (one in each village) by involving the village head and three farmers, selected purposively based on their knowledge about the village and surrounding areas.

Five focus group discussion (FGD) sessions (one in each village[8]) and field observations were used to identify the types of local cultivation systems and their products. The village heads and local farmer representative groups (consisting of eight to twelve farmers[9]) were present in the FGD sessions. Field observations were carried out in fifty-five farm locations identified during the RRAs and FGDs. Several pictures of local cultivation systems were taken[10], and relevant information was noted with the assistance of expert local informants[11].

Semi-structured interviews were conducted to collect information on farm products and their values, land area and allocation, and other basic characteristics of the farm household, i.e. family and labor force size, age and education of the family members, income, expenditure, savings and interest in

[6] In the Indonesian study site, the national government is the owner of the land. Individuals and communities have land use and transfer rights. Individuals and communities have no formal rights to state forest land but, with government agreement, people can collect NTFP.

[7] In the Bangladesh study site, the national government is the owner of the land. Individuals and communities have the right to use the land, but no transfer rights. Individuals and communities have no formal rights to state forest land but, with government agreement, people can collect NTFP.

[8] One semi-structured questionnaire interview (village survey, consisting of a set of questions regarding basic information about the village, e.g. demographic, infrastructure, land use) was also conducted during the FGD.

[9] Farmers in each group were purposively selected based on their knowledge of local cultivation systems.

[10] Pictures were taken as visual supporting evidence to aid data analysis and interpretation by characterising the structure of each specific cultivation system.

[11] One person from each research site (country), who had considerable knowledge of local land use systems, products, markets and institutions, was employed as an expert local informant. These informants were present during the whole period of fieldwork, and helped check the validity of information obtained.

tree-based farming. In Indonesia 20 permanent monoculture[12], 20 swidden and 20 agroforestry farmers were interviewed; and in Bangladesh[13] 40 swidden and 21 agroforestry farmers were interviewed. Due to the variation in structure and management practices of the farms in each area, purposive sampling was used to identify households that were practicing a well-managed[14] form of each of the contrasted farming systems[15]. We estimate that in the Indonesian study villages they represent 20%, 40% and 30% of the permanent monoculture, swidden and agroforestry farming populations respectively. In the Bangladesh study villages they represent about 50% and 60% of the swidden and agroforestry farming populations respectively. The questionnaire that guided the interviews was refined and finalized with the help of the expert local informants and during FGD sessions to make sure that the questions elicited the information required. The product value of crops was calculated with the key informant farmers during the interview based on the total production in the most recent season/year.

The primary data (i.e. local farm production and its market value) collected from the research sites were cross-checked with data gathered from local state agriculture and forestry offices, and the ICRAF Southeast Asian Regional office and CIFOR headquarters (both located in Bogor, Indonesia).

Data Analysis

Descriptive statistics were used to compare characteristics (age, education, family size, farm size, yearly income and expenditure) of the different farmer groups[16]. The size of farms and proportion of land used for different categories of land use were compared amongst the farmer groups. To compare two farmer groups, a two-sample un-paired Student’s t-test (t) was calculated, with the assumption of unequal variance, and the Welch (or Satterthwaite) approximation to the degrees of freedom (df) was used to determine the p-value. ANOVA was used to test differences amongst three farmer groups, with F-statistics reported as F (*a*, *b*), where *a* and *b* are between and within group degrees of freedom

[12] In this research, permanent monoculture refers to growing a single crop at given times of the year in a rotational system in the same area without abandoning the land.

[13] In the Bangladesh research site permanent monoculture is rarely practiced, with insufficient farmers in the studied villages to provide an adequate sample, thus it was not included in the study.

[14] For example, some farmers started agroforestry farming but after a few years gave up planting the understorey, for various reasons (e.g. lack of management interest or capital). Thus, many agroforestry farms were converted to simple tree orchards, and we have excluded these from our sample.

[15] Each of these farmer groups as a whole cultivates plots of land under different forms of farming (agroforestry, swidden, permanent monoculture). Therefore, each group was selected on the basis of their dominant form of farming practice.

[16] Descriptive statistics are abbreviated: M = mean, SD = standard deviation and N = sample size.

respectively. All analyses were performed in the R environment for statistical computing (version R 2.15.0) (R Core Team 2015) in a Windows platform.

Net present value (NPV) was calculated to assess the overall economic performance of crop production under mixed tree crops *versus* the non-agroforestry farming systems (swidden and permanent monoculture) on the basis of a 30-year time period (Rahman et al., 2007; 2014; Arun 2013) and a 10% discount rate as it is an appropriate rate to match the banking system local to the research site (Rahman et al., 2007; 2014)[17]. Sensitivity analysis was also conducted on variation in yields, as the combination of tree species may affect understorey crop production. Means are compared (independent sample t-test using SPSS V 22) to assess the different factors that may affect the decisions of non-agroforestry (swidden and permanent monoculture) farmers to choose to adopt agroforestry tree-based farming, by determining the conditional probability that a farmer will adopt given a set of independent influencing factors, i.e. land area, family size, income, age, education, and credit availability (Rahman et al., 2012; Mai, 1999). Our hypothesis is that, with less land available for permanent cultivation, farmers are more inclined to practice seasonal cultivation, e.g. swidden. Farmers with larger family size, lower family income, who are older, and less-educated are also more closely aligned to seasonal cultivation. Available credit helps to enable the adoption of agroforestry. The dependent variable in our case is binary which takes the value ‘1’ if a non-agroforestry farmer wants to practice agroforestry and ‘0’ if otherwise. The definition and expected signs of the explanatory variables and the results are described in Table 1.7.

Results

In both study sites, agroforestry farmers are younger than swidden farmers (Table 1.2). In addition, in the Indonesian case, the farmers in the lower watershed village practicing permanent monoculture were of comparable age to the swidden farmers in the two villages higher in the watershed. All the Indonesian farmer groups have roughly the same educational qualifications, whereas in Bangladesh the agroforestry farmers have higher levels of education than the swidden farmers. In both areas all respondents and household heads were male. The average household labor force size is 1.2, 1.4 and 1.5 for agroforestry, swidden and permanent monoculture farmers in Indonesia, and 1.6 for both the agroforestry and swidden farmers in Bangladesh. Agroforestry farmers have higher annual income than swidden farmers in both areas. In Indonesia, the permanent monoculture farmers have higher

[17] Further details of the NPV calculation are given in Appendix 1, including the yearly cash flow results for selected cultivation systems in the research sites in Appendix 1, Table 1.

income than the others. The savings of Indonesian farmers are lower than Bangladeshi farmers. They do not differ much amongst the farming groups in Indonesia, however agroforestry farmers in Bangladesh have double the amount of savings (US$ 481.14) of swidden farmers (US$ 240.69).

Table 1.2: Basic characteristics of the farm households.

Characteristics	Indonesia			Bangladesh	
	AF (n=20)	SW (n=20)	PM (n=20)	AF (n=21)	SW (n=40)
Age of household head	53	60	59	42	45
Education of household head (year of schooling)	5.0	5.1	4.8	6.0	3.7
Sex of household head	Male (100%)	Male (100%)	Male (100%)	Male (100%)	Male (100%)
Family size	6.7	4.7	4.9	4.7	4.8
Labour force (age15-59)	1.2	1.4	1.5	1.6	1.6
Distance to the village center (minutes of walking)	23.5	12.8	12.9	5.7	8.2
Distance to the edge of nearest forest (minutes of walking)	10.6	24.0	9.2	21.3	16.9
Total land area (ha)	0.98	0.77	0.26	3.72	2.22
Total annual income (US$)	2015	1207	2497	1380	1076
Total annual expenditure (US$)	1454	1114	2109	1397	1069
Total savings in a bank/credit association (US$)	126	172	168	481	241
Total outstanding debit (US$)	8.50	7.50	9.50	177.01	182.56

Note: AF = Agroforestry farmer, SW = Swidden farmer, PM = Permanent monoculture farmer. US$ 1 = 10,000 Indonesian Rupiah (IDR) or 78 Bangladeshi Taka (BDT).

Each of the farmer groups as a whole cultivates plots of land under different forms of farming (Figure 1.2). The total farm size of agroforestry farmers is significantly larger (M = 3.7 ha, SD = 2.8, N = 21) than that of swidden farmers (M = 2.2 ha, SD = 2.2, N = 40) in Bangladesh (t = 2.28, df = 24.59, p-value = 0.03) (Figure 1.1). In Indonesia, farm size also differs between the groups [F (2.57) = 6.4, p = 0.003], with swidden and agroforestry farms in the middle and upper watershed villages being significantly larger than the permanent monoculture farms in the lower watershed village. However, there was no significant difference in farm size between the swidden and agroforestry farmers (t = 0.8, df = 20.6, p-value = 0.38).

The proportion of the total land area of the interviewed agroforestry farmers that they use for agroforestry systems (M = 61%, SD = 32%, N=41) is significantly higher than that the swidden farmers use for swidden systems (M = 47%, SD = 21%, N = 60) (t = 2.37, df = 63.1, p-value = 0.02). The allocation of land to 'other land uses' follows a similar pattern for the two groups of farmers (Figure 1.2).

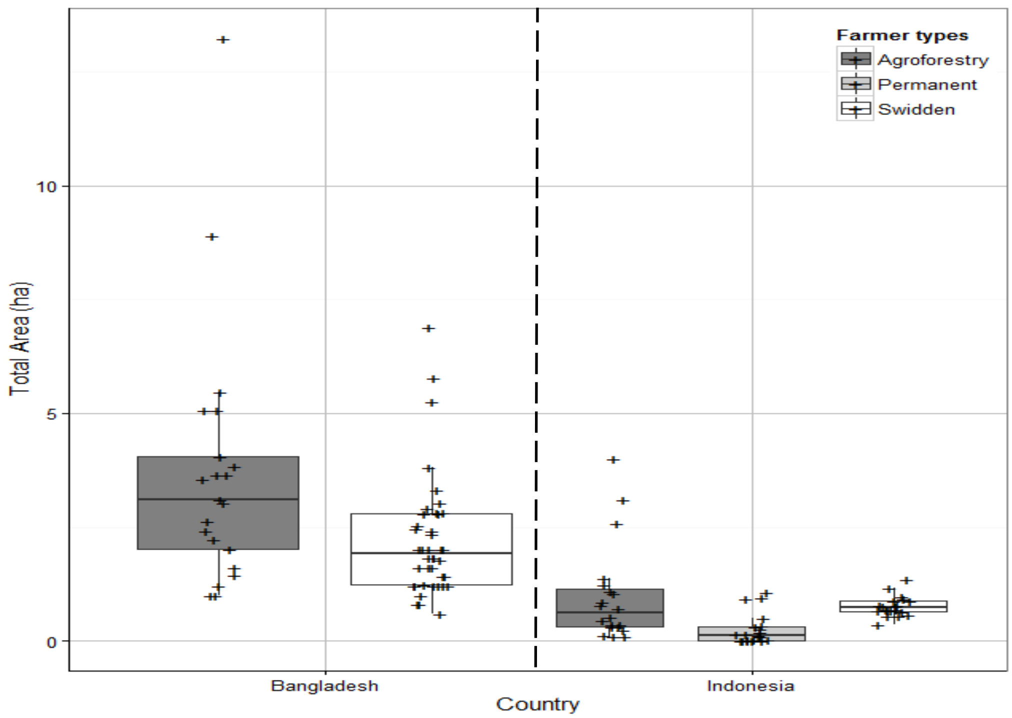

Figure 1.1: Boxplot showing total farm size (ha) amongst the different farmer groups. For each box the horizontal center line shows the median of the distribution, the top and bottom edges of the box show the 75% (Q3) and 25% (Q1) quartiles respectively, and the top and bottom ends of the whiskers are defined as the first data point within the limits defined by Q3+(1.5*IQR) and Q1-(1.5*IQR) respectively, where IQR is the inter-quartile range (the box height).

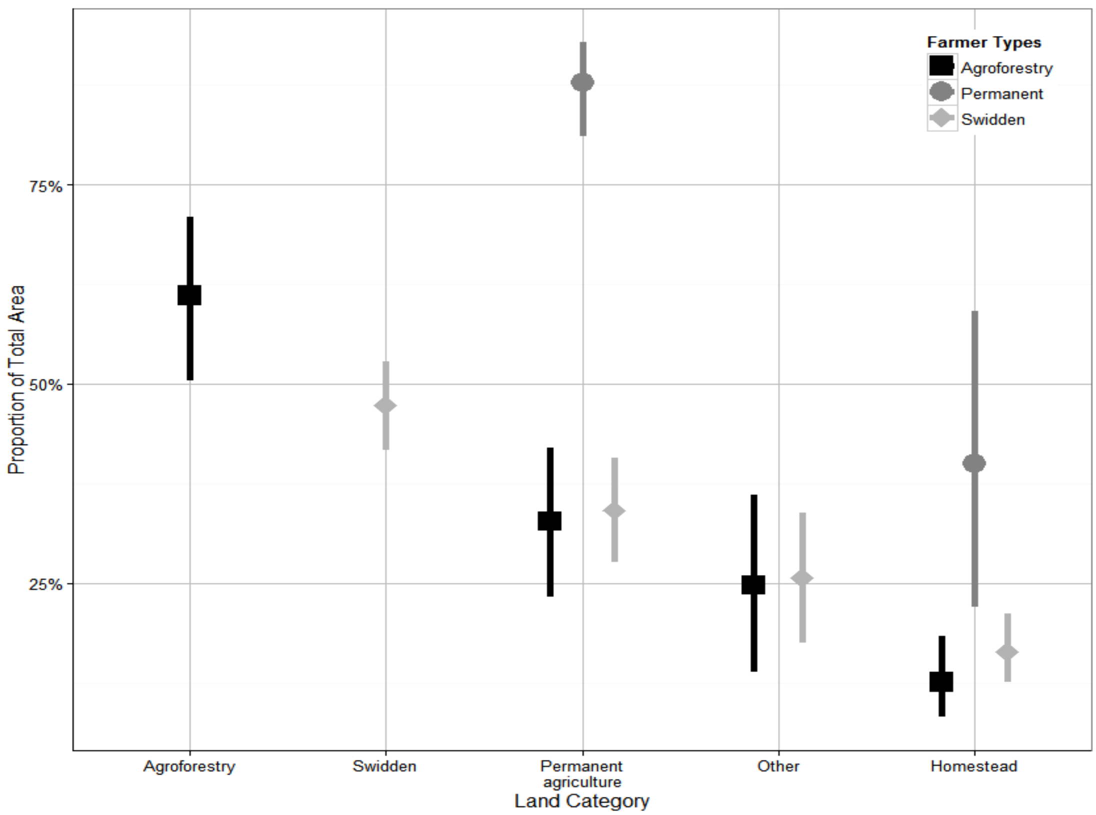

Figure 1.2: The proportion of their total land area used for various forms of farming amongst the different farmer groups[18]. The square, diamond and circle symbols show the mean values and the ends of the vertical lines show +/- 1 standard deviation.

The agroforestry farmers tend to cultivate a single plot of land. In Indonesia, on average the agroforestry farmers allocate 88% of their land to the single largest plot, whereas in Bangladesh it is only 58% of their land (Figure 1.3). This indicates that the land of the Bangladeshi agroforestry farmers tends to be divided into more plots with a greater diversity of plot sizes. In contrast, for the swidden farmers there is less difference between the two countries in the division of their land between plots of different sizes; in both cases the proportion of their land that is allocated to their largest plot varies widely amongst farmers. This is because there is a tendency to spread the farming risk[19] across many smaller plots. In contrast, the vast majority of permanent monoculture farmers allocated a very high proportion of their land to their single largest plot (on average 91%).

[18] The 'other' land use type includes fallows, wetlands and ponds. 'Homestead' refers to a farmhouse surrounded by carefully managed, planted and naturally grown plants, e.g. fruits, vegetables and ornamentals.
[19] During the FGDs farmers reported that in the swidden system there is a farming risk, which is associated with crop failure, landslides, and land grabbing by more powerful actors.

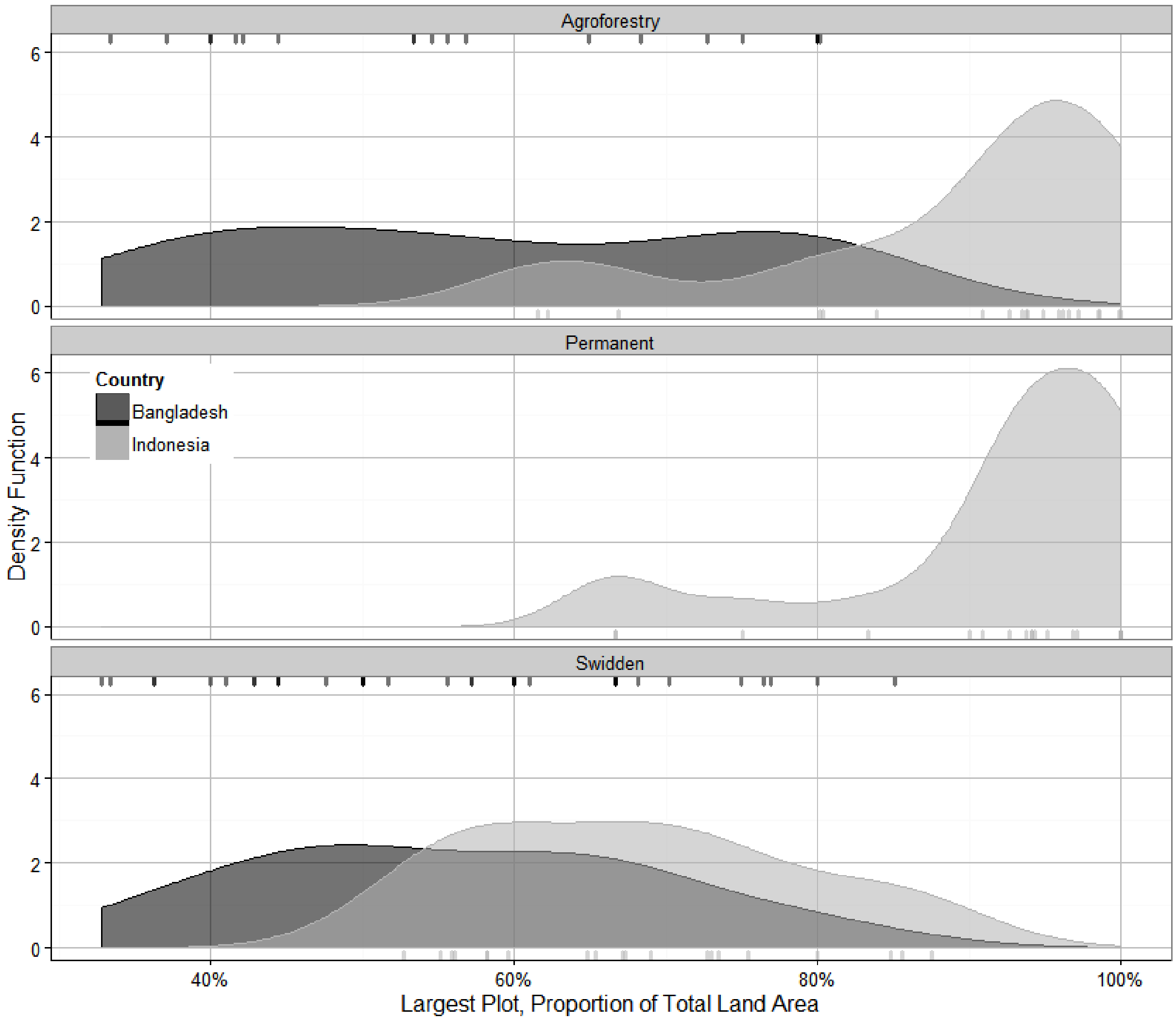

Figure 1.3: Comparison amongst farmer groups in the probability of their largest plot occupying different proportions of their land area. Kernel density plots showing the concentration of observations as a density function against the percentage of their land area occupied by their largest plot for the farmers in each group (agroforestry, swidden and permanent monoculture). The kernel density estimation model used to generate each curve fixes its integral as 1 across the modelled range from 33% to 100% of land area. The probability between two x-values is the area under the curve between those two points. The Kernel density analysis was carried out using R, version R 2.15.0.

In the Indonesia study site, the agroforestry farmers earn an average income of US$382 per hectare of land that they allocate to agroforestry (Table 1.3). This is 1.7 times higher than the income of swidden farmers per hectare of land allocated to swidden (US$226). However, the average income of the permanent monoculture farmers located lower in the watershed, who allocated 100% of their mean

0.20 ha of land to this use, was much higher (US$2990 ha^{-1}). In contrast, in Bangladesh the swidden farmers had a higher income per area of land used for swidden (US$610 ha^{-1}) than the agroforestry farmers had per area of agroforestry land (US$441 ha^{-1}). In Bangladesh the two groups of farmers allocated a similar proportion of their land (ca. 30%) to their dominant land use (agroforestry and swidden respectively), whereas in Indonesia agroforestry farmers allocated 87% of their land to this use, but swidden farmers allocated a lower proportion (60%) of their land to swidden.

Table 1.3: Farm households' allocation of their land area (ha) to different farming systems and the annual income (US$) from total production on each[20].

			Indonesia			Bangladesh	
			Agroforestry farmer	Swidden farmer	Permanent monoculture farmer	Agroforestry farmer	Swidden farmer
Land area and income share	Agroforestry land	Area (ha) and proportion of total land (%, in brackets)	0.85 (86.73)	0.00	0.00	1.07 (28.76)	0.00
		Income (US$) and share of total farm income (%, in brackets)	324.55 (66.11)	n/a	n/a	472.20 (45.13)	n/a
	Swidden land	Area (ha) and proportion of total land (%, in brackets)	0.00	0.46 (59.74)	0.00	0.00	0.71 (31.98)
		Income (US$) and share of total farm income (%, in brackets)	n/a	104.00 (29.21)	n/a	n/a	433.34 (67.32)
	Permanent monoculture land	Area (ha) and proportion of total land (%, in brackets)	0.11 (11.22)	0.29 (37.66)	0.20 (76.92)	0.92 (24.73)	0.51 (22.97)
		Income (US$) and share of total farm income (%, in brackets)	166.35 (33.89)	252.00 (70.79)	598.08 (100)	574.12 (54.87)	210.38 (32.68)
Total farm income (US$) and share of total household income (%, in brackets)			490.90 (24.36)	356.00 (29.49)	598.08 (23.95)	1046.32 (75.80)	643.72 (59.81)

[20] The level of annual income from products harvested from different farming systems was based on farmers' reports of their income during the single most recent production year. However, for most of the agroforestry farmers this underestimated their potential future income as the timber trees in their agroforests had yet to reach harvestable maturity and in some cases fruit trees had yet to grow to maturity and achieve maximum fruit yield. Since tree species have a longer juvenile period compared with other agricultural crops such as rice and maize that mature within a few months, income from agroforestry systems will be much lower during the years of their establishment phase.

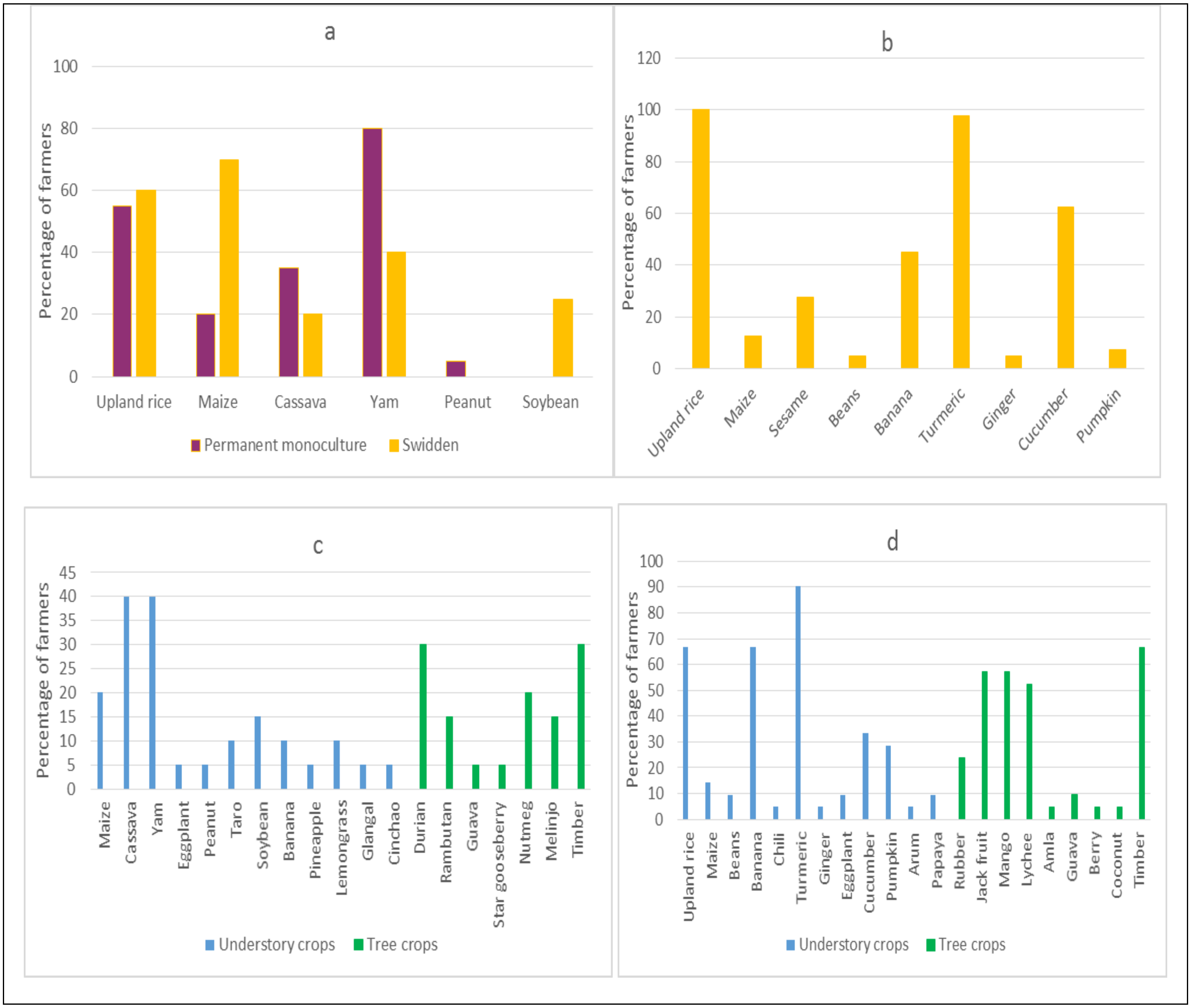

Figure 1.4: The percentage of farmers cultivating each type of subsistence crop (a, Indonesia swidden and permanent monoculture; b, Bangladesh swidden; c, Indonesia agroforestry; d, Bangladesh agroforestry).

Farmers in our study sites spread their production over a wide diversity of crops (Figure 1.4). In Indonesia, yam is the most common permanent monoculture crop, being cultivated by 80% of farmers. Among swidden farmers, maize and upland rice are most popular. On agroforestry farms, the most common crops are the annuals cassava and yam, followed by the fruit trees durian and nutmeg and the timber trees teak and white jabon. In Bangladesh, turmeric, rice and banana are the most widely cultivated field crops, mangium the dominant timber tree, and mango, jackfruit and lychee the dominant fruit trees for agroforestry farmers. The surveyed agroforestry farmers in Indonesia do not grow rice in their agroforestry fields, but in separate non-agroforestry fields. The average income and net present value (NPV, on the basis of a 30-year time period and 10% discount rate) of the main agricultural crops grown in the swidden and permanent monoculture systems is presented in Table 1.4. Among the crops, yam generated the highest income (mean income during its cultivation period was US$1,531.40 ha^{-1}, NPV= US$14,436.38 ha^{-1}) in Indonesia followed by upland rice, maize and peanut. In Bangladesh farmers earn the highest income from banana (mean income US$6,175.00 ha^{-1}, NPV= US$58,211.00 ha^{-1}) followed by turmeric, cucumber, maize and upland rice.

To test the difference in overall economic performance (NPV) of farm production under agroforestry, with a mixture of tree crops, to that of non-agroforestry farming systems (swidden and permanent monoculture), the most popular locally cultivated trees were selected: durian, nutmeg and teak in Indonesia; mango, jackfruit, lychee and mangium in Bangladesh. Risk factors, such as the effect that the tree species combination may have on productivity of the understorey crops are important in assessing economic performance. This effect depends on various factors, e.g. intensity of shade and spread of tree canopy, sunlight, rainfall, soil conditions and fertilizer inputs. Therefore, sensitivity analysis was conducted testing the effect of variation in crop yield reduction in 10% intervals from 0% to 60% on the NPV (Table 1.5 and 1.6). With durian as the overstorey tree crop, all of the understorey crops, except yam, are profitable up to yield reductions of 40% compared with other cropping systems (Table 1.5, Table 1.4) in Indonesia. Nutmeg as a tree crop provides a low return (NPV) and the nutmeg system is not profitable at any level of crop loss. In contrast, teak has high value so the teak-based agroforestry system remains profitable regardless of the understorey crop yield reduction it may cause. Similarly, in Bangladesh mango- and lychee-based agroforestry systems are profitable regardless of the yield reduction with any selected crops except banana, which is profitable up to 30% loss. The jackfruit-based system is profitable up to 50% loss of most crops, but there is a big variability in the mangium system as rice, maize, sesame, turmeric and cucumber are profitable up to 30%, 20%, 40%, 10% and 10% of crop yield reduction respectively. In contrast banana is never profitable with mangium.

Table 1.4: Income from main agricultural crops (US$ ha^{-1}), when grown in open fields[21].

Crop and cultivation period	Indonesia		Bangladesh	
	Mean	NPV	Mean	NPV
Upland rice (3 months)	1,282.90	12,093.79	1,140.00	10,747.00
Maize (4 months)	1,213.90	11,443.33	1520.00	14,329.00
Yam (4 months)	1,531.40	14,436.38	n/a	n/a
Cassava (8 months)	1,134.40	10,693.89	n/a	n/a
Peanut (4.5 months)	1,191.40	11,231.23	n/a	n/a
Soybean (3 months)	300.00	2,828.07	n/a	n/a
Sesame (3 months)	n/a	n/a	902.50	8,508.00
Turmeric (10 months)	n/a	n/a	2,422.50	22,837.00
Cucumber (4 months)	n/a	n/a	2,066.25	19,478.00
Banana (10 months)	n/a	n/a	6,175.00	58,211.00

Data sources: focus group discussion, farm level semi-structure questionnaire interview, Local Agricultural Office, ICRAF, CIFOR.

[21] The calculation of NPV is based on a 30-year time horizon, a 10% discount rate, and one harvest per crop per year regardless of its cultivation period, as farmer decision-making about whether to combine crops in the same year is too complex to model.

Table 1.5: Sensitivity of overall profitability (NPV in US$ ha^{-1}) to decreases in production of six understorey crops resulting from competition with three different overstorey tree species[22] in agroforestry systems in Indonesia [23].

Decrease of production	Durian tree (NPV 4,849.42) + the understorey crops					
	Upland rice	Maize	Yam	Cassava	Peanut	Soybean
0%	16,943.21	16,292.75	19,285.80	15,543.31	16,080.65	7,677.49
10%	15,733.83	15,148.42	17,842.16	14,473.92	14,957.52	7,394.69
20%	14,524.45	14,004.09	16,398.52	13,404.53	13,834.40	7,111.88
30%	13,315.54	12,859.75	14,954.88	12,335.14	12,711.28	6,829.07
40%	12,105.69	11,715.42	13,511.25	11,265.76	11,588.16	6,546.27
50%	10,896.31	10,571.09	12,067.61	10,196.37	10,465.03	6,263.46
60%	9,686.94	9,426.75	10,623.97	9,126.98	9,341.91	5,980.65
	Nutmeg tree (NPV 516.15) + the understorey crops					
	Upland rice	Maize	Yam	Cassava	Peanut	Soybean
0%	12,609.94	11,959.48	14,952.52	11,210.04	11,747.37	3,344.22
10%	11,400.56	10,815.15	13,508.89	10,140.65	10,624.25	3,061.41
20%	10,191.18	9,670.81	12,065.25	9,071.26	9,501.13	2,778.61
30%	8,981.80	8,526.48	10,621.61	8,001.87	8,378.01	2,495.80
40%	7,772.42	7,382.15	9,177.97	6,932.48	7,254.88	2,212.99
50%	6,563.04	6,237.81	7,734.34	5,863.09	6,131.76	1,930.18
60%	5,353.66	5,093.48	6,290.70	4,791.82	5,008.64	1,647.38
	Teak tree (NPV 17,116.38) + the understorey crops					

[22] Fruit trees (durian, nutmeg) and timber tree (teak).
[23] NPV is calculated based on a 30-year time horizon with a 10% discount rate. Once trees are included in the cultivation system the lifespan of the project can be considered indefinite. However, for simplicity, in our analysis the project life is still considered to be 30 years as this may be a realistic lifetime for one productive rotation of fruit trees (durian and nutmeg), and for three rotations (harvest cycles) of the timber tree (teak). Yields of durian and nutmeg (from grafted seedlings) are calculated in three periods: durian has low yields during the fourth to sixth years, medium yields during the seventh to eighth years, and high yields from the ninth year onwards; nutmeg has low yields during the seventh to ninth years, medium yields during the tenth to twelfth years, and high yields from the thirteenth year onwards. The calculation for each understorey crop is based on 30 annual productions assuming constant income cycles, i.e. one production per year regardless of its cultivation period, as farmer decision-making about whether to combine crops in the same year is too complex to model.

	Upland rice	Maize	Yam	Cassava	Peanut	Soybean
0%	29,210.17	28,559.71	31,552.76	27,810.27	28,347.61	19,944.45
10%	28,000.79	27,415.38	30,109.12	26,740.88	27,224.48	19,661.64
20%	26,791.41	26,271.04	28,665.48	25,671.49	26,101.36	19,378.84
30%	25,582.03	25,126.71	27,221.84	24,602.10	24,978.24	19,096.03
40%	24,372.65	23,982.38	25,778.20	23,532.71	23,855.11	18,813.22
50%	23,163.27	22,838.04	24,334.57	22,463.32	22,731.99	18,530.41
60%	21,953.89	21,693.71	22,890.93	21,393.93	21,608.87	18,247.61

Table 1.6: Sensitivity of overall profitability (NPV in US$ ha^{-1}) to decreases in production of six understorey crops resulting from competition with four different overstorey tree species[24] in agroforestry systems in Bangladesh[25].

Decrease of production	Mango tree (NPV 20,768) + the understorey crops					
	Upland rice	Maize	Sesame	Turmeric	Cucumber	Banana
0%	31,515.02	35,097.24	29,276.12	43,605.03	40,246.70	78,979.53
10%	30,440.35	33,664.35	28,414.32	41,321.36	38,298.81	73,158.41
20%	29,365.68	32,231.46	27,570.79	39,037.69	36,351.02	67,337.29
30%	28,291.01	30,798.57	26,720.49	36,754.02	34,403.14	61,516.17
40%	27,216.34	29,365.68	25,870.18	34,470.35	32,455.35	55,695.05
50%	26,141.67	27,932.79	25,019.87	32,186.68	30,507.47	49,873.93
60%	25,067.01	26,499.90	24,169.56	29,903.01	28,559.68	44,052.81
	Jackfruit tree (NPV 11,386) + the understorey crops					
	Upland rice	Maize	Sesame	Turmeric	Cucumber	Banana
0%	22,133.05	25,715.27	19,894.15	34,223.06	30,864.73	69,597.56
10%	21,058.38	24,282.38	19,032.35	31,939.39	28,916.84	63,776.44
20%	19,983.71	22,849.49	18,188.83	29,655.72	26,969.05	57,955.32

[24] Fruit trees (mango, jackfruit, lychee) and timber tree (mangium).

[25] NPV is calculated based on a 30-year time horizon with a 10% discount rate. Yields of mango, lychee and jackfruit (from grafted seedlings) are calculated in three periods: mango and lychee have low yields during the sixth to eighth years, medium yields during the ninth to eleventh years, and high yields from the twelfth year onwards; jackfruit has low yields during the sixth to seventh years, medium yields during the eighth to ninth years, and high yields from the tenth year onwards. The market value of timber from mangium is calculated in ten-year rotation periods, after which it is assumed that it is replanted. The calculation for each understorey crop is based on 30 annual productions assuming constant income cycles, i.e. one production per year regardless of its cultivation period, as farmer decision-making about whether to combine crops in the same year is too complex to model.

30%	18,909.04	21,416.60	17,338.52	27,372.05	25,021.17	52,134.20
40%	17,834.37	19,983.71	16,488.21	25,088.38	23,073.38	46,313.08
50%	16,759.71	18,550.82	15,637.90	22,804.71	21,125.50	40,491.96
60%	15,685.04	17,117.93	14,787.60	20,521.04	19,177.71	34,670.84
	Lychee tree (NPV 19,006) + the understorey crops					
	Upland rice	Maize	Sesame	Turmeric	Cucumber	Banana
0%	29,752.28	33,334.51	27,513.39	41,842.30	38,483.96	77,216.80
10%	28,677.61	31,901.62	26,651.58	39,558.63	36,536.08	71,395.68
20%	27,602.95	30,468.73	25,808.06	37,274.96	34,588.29	65,574.56
30%	26,528.28	29,035.84	24,957.75	34,991.29	32,640.41	59,753.44
40%	25,453.61	27,602.95	24,107.45	32,707.62	30,692.62	53,932.32
50%	24,378.94	26,170.05	23,257.14	30,423.95	28,744.73	48,111.20
60%	23,304.27	24,737.16	22,406.83	28,140.28	26,796.94	42,290.08
	Mangium tree (NPV 3,570) + the understorey crops					
	Upland rice	Maize	Sesame	Turmeric	Cucumber	Banana
0%	14,317.08	17,899.31	12,078.19	26,407.10	23,048.76	61,781.60
10%	13,242.41	16,466.42	11,216.38	24,123.43	21,100.88	55,960.48
20%	12,167.74	15,033.53	10,372.86	21,839.76	19,153.09	50,139.36
30%	11,093.08	13,600.64	9,522.55	19,556.09	17,205.21	44,318.24
40%	10,018.41	12,167.74	8,672.24	17,272.42	15,257.42	38,497.12
50%	8,943.74	10,734.85	7,821.94	14,988.75	13,309.53	32,676.00
60%	7,869.07	9,301.96	6,971.63	12,705.08	11,361.74	26,854.88

From the information gathered during our semi-structured interviews of the non-agroforestry famer groups (swidden and permanent monoculture), a comparison of means is used to investigate the conditional probability that a farmer may adopt tree-based farming given a set of influential factors. The mean values of different influential factors, i.e. farmer age, education, land area, family size, income and credit availability, revealed no significant differences between those who have a (potential) interest in agroforestry and those who have not, in either country, except that interest in adopting agroforestry was very significantly associated with educational level for swidden (but not permanent monoculture) farmers in Indonesia (Table 1.7). Therefore, with this exception, there is no evidence that these factors have a significant influence on farmer choice of tree-based farming in our study areas, which is corroborated by the qualitative information obtained from FGD sessions that swidden and permanent monoculture are retained because they are deeply rooted in local traditions extending back over many generations.

Table 1.7: Farmers interest in adopting agroforestry.

Variables	Definition	Expected signs	Indonesia		Bangladesh
			Swidden	Permanent monoculture	Swidden
			p-value	p-value	p-value
AGE	Decision maker's age in years	+	0.966	0.710	0.713
EDUCATION	Decision maker's educational qualification (total years of schooling)	+	**< 0.001**	0.923	0.339
LAND	Household total land area (ha)	+	0.477	0.057	0.222
HOUSEHOLD SIZE	Total number of people in the household (persons)	+	0.907	0.210	0.559
INCOME	Household total income (US$)	+	0.408	0.977	0.251
CREDIT	= 1 if the farmer got credit from any sources, and 0 otherwise	+	0.331	0.498	0.160

Note: Significant value at $p < 0.05$ is indicated in bold

Discussion

Profitability measured by NPV over a 30-year time period shows that farmers will achieve a positive economic performance by mixing trees and seasonal crops in agroforestry systems compared with seasonal agriculture in both countries. This finding holds across a wide range of percentage reductions in understorey crop production when trees become mature and their canopies close. Teak-based agroforestry systems, followed by durian, showed the best economic performance at the Indonesian site, both considerably outperforming seasonal crop-based farming systems. Agroforestry systems with two fruit tree species, mango and lychee, also showed a good economic performance in Bangladesh. In the short term, however, before tree crops have reached maturity, permanent monoculture and swidden farms provide higher income, as seasonal crop farms generate quicker returns than do agroforestry farms. Furthermore, when adopting tree crops, farmers have to accept reduced yields of understorey seasonal crops before receiving the increase in income from harvesting these tree crops (Oladele and Popoola, 2013; Singh et al., 2012; Tiwari et al., 2012). Farmers may also face other interacting risks, such as crop failures, fluctuating market demand and prices, pests and diseases, and climate change. Changing successfully to tree-dominated systems will require farmers to develop access to high quality tree germplasm, tree management expertise, which may be lacking in government extension services, and market channels for tree products, which are generally different from those for annual crops. Nonetheless, a more ecologically diverse farming system yielding a wider range of products is more likely to be buffered against such risks over the 30-year time period assessed in this paper (Elevitch and Wilkinson, 2000). This change in farming system to agroforestry may, however, have serious subsistence and cultural costs as the cultivation of seasonal crops is primarily for household subsistence consumption and is deeply rooted in their culture. The retention of seasonal crop farming by many farmers, despite the medium-/long-term economic advantage of adopting agroforestry demonstrated by the results of the present study, is likely to be explained by culture- and tradition-linked factors retaining a decisive influence on farmer preferences. This is also indicated by their retention of comparatively small plots of seasonal crops, despite this restricting the efficiency of the productive assets (Rahman et al., 2012).

Farmers are concerned about the loss of understorey crop production in agroforestry systems, however our results provide strong evidence that these will be compensated by the generation of cash income from tree products in the medium-term. Provided that farmers can afford to bear the losses up to the time that their trees have grown to harvestable maturity, they are likely to gain a net benefit by achieving a level of income from tree products that enables them to purchase essential needs including food. However, farmers may lack confidence in this shift in the basis of their livelihoods. Even if it is likely to increase their net income, they may feel more exposed to risks of market failure of their tree crops and regret the loss of cultural identity associated with the cultivation of specific traditional crops (Mwase et al., 2015; UEA, 2015; Gyau et al., 2014; Pannell, 2009). Thus, smallholder farmers' decision-making about whether to shift their food production system to agroforestry in place of subsistence crop production is based on cultural considerations as well as the trade-off between short-term and a longer-term benefits.

Living costs are predicted to increase in both the studied countries, however as food security largely depends on income security, even in remote places (van Noordwijk et al., 2014), our economic analyses demonstrate that the higher income from tree-based farming has the potential to enhance food security. Incorporation of tree species selected for the local value of their products (fruit, timber) into food-crop-based subsistence agricultural systems can also enhance household well-being by consumption of a more diverse diet of higher nutritional quality, both from the harvested fruit and from foodstuffs that can be purchased with the income generated. In this sense, farming families may increase their food sovereignty through improved access to healthy and culturally appropriate food (Vira et al., 2015; Edelman et al., 2014).

The higher establishment costs of agroforestry systems than traditional agricultural alternatives indicated by the present study can be attributed to their distinction from established routines of seasonal farming (Rahman et al., 2008). All of the farmers in our study site are poor[26] (Table 1.2), therefore initial capital support could be helpful to facilitate local adoption of agroforestry. Furthermore, the farmers do not have full tenure rights to the land as it is owned by the state (Table 1.1). Therefore, swidden farmers tend to establish many small swidden plots across the landscape to spread risk[19] (Figure 1.3), and this practice is viewed as a major cause of tropical deforestation (Peng et al., 2014; Rahman et al., 2012). In contrast, agroforestry tends to be established in larger plots, reflecting the greater investment by households in this longer-term (more permanent) farming practice (Rahman et al., 2014; Michon, 2005). Tenure security is an important factor influencing land use decisions (Rahman et al., 2007; Feder et al., 1988). To adopt agroforestry instead of traditional seasonal cultivation, farmers need to invest substantial amounts of financial and labor resources. Insecure land tenure constrains such investments and has induced farmers to continue their traditional land use practices (Rasul and Thapa, 2003).

To adopt tree-based agroforestry systems, farmers may also need to develop a different set of skills, knowledge and technologies (Schultz, 1964), and the present study did find evidence of a strong positive association between education level and interest in adopting agroforestry within one group of farmers (those practicing swidden in Indonesia). Others (Roshetko et al, 2007b; Lipton, 1989; Binswanger, 1987) argue that smallholder farmers cannot use improved technology when structural constraints are imposed by institutions. Institutions not only govern the processes by which scientific and technical knowledge is created, but also facilitate the introduction and use of new technology in agricultural production. The equally important role of infrastructure, including transportation facilities and access to market centres, in facilitating land use change has been emphasised by Reardon et al. (2001), Turkelboom et al. (1996) and Allan (1986) as they increase the potential income from new crops and technologies. In Lampung, Indonesia a team of socioeconomic, forestry, horticulture and livestock specialists determined that smallholder agroforestry systems and the productivity of those systems are limited by a lack of technical information, resources and consultation (Gintings et al., 1996). Experience from across Indonesia shows that farmers' previous agricultural knowledge, quality of land resources, proximity to markets and level of support received (both technical and through policy) all play important roles in determining the technology adopted and subsequent success (Roshetko et al., 2007b; Potter and Lee, 1998; Gintings et al., 1996). Therefore, the motivation of self-interest – the desire to profit from their investment of time and resources – is invaluable for farmers'

[26] As indicated by their daily income being less than US$1.25 per person. The US$1.25 level at 2005 purchasing power parity is essentially set the same way by the World Bank as the original US$1 per day poverty line (World Bank, 2015).

success, once skills, knowledge, and institutional support have been secured (Roshetko et al., 2008; Rasul and Thapa, 2007). If these institutional and policy requirements can be met, then agroforestry systems have great potential as a 'land sharing' option in the marginal farmlands that efficiently combines provision of local food security and environmental services of benefit to a wider population, instead of the 'land sparing' separation of agriculture and forests (Lasco et al., 2014; van Noordwijk et al., 2014).

Conclusions

The economic assessment of tree-based faming in our research shows higher net present value than that of seasonal agricultural systems in both West Java and eastern Bangladesh. Trees also help diversify farm products, which can potentially improve household nutrition and welfare. In both locations, agroforestry is a practice that has already been adopted by some households and this establishes the set of tree species that are popular in each location to incorporate into food-crop-based agricultural systems. This represents diversification of farming based on a combination of locally favoured tree and agricultural crops. Nonetheless, the cultural value of retaining the practice of seasonal agriculture with a narrow set of traditional subsistence food crops still has the potential to inhibit farm diversification through agroforestry. This resistance to changing farming practice is likely to be reinforced by the inability of many households to cope with the short-term loss of food crop productivity during the tree crop establishment phase, before tree products can be harvested resulting in longer-term net benefits. Insecurity of land tenure compounds this risk. Therefore, to implement such an initiative on the ground, a strong and long-term institutional framework is needed to provide more secure land tenure, and short-term technical and financial support (initial capital provided by NGO and Government agencies) during the tree establishment phase. The success of this framework will be greatly facilitated by the development and implementation of government policy involving a broad cross-section of local people to incorporate their aspirations, and sensitivity to their cultural values, in the planning and decision-making processes. This will also require provision of technical extension based on expert knowledge of tree planting and management, which is likely to benefit from further research. Participatory research may play a particularly valuable role in the areas of plant breeding to match local needs and the ecological functioning of agroforestry systems (Witcombe et al., 1996). This could result in agricultural sovereignty and self-sufficiency being operationalized spontaneously by the farmers in a smallholder tree-based farming environment that could lead to increases in tree cover in the agricultural landscape.

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Appendix 1:

Assumptions for the calculation of Net Present Value:

The market for agricultural land is underdeveloped in the study areas, therefore the price of land is unstable and difficult to identify. However, as mentioned by MacDicken and Vergara (1990)[27], there is no need to value the land separately if farmers want to change their existing cultivation system to another. Thus, in our cash flow analysis the land value is omitted from the calculation (Table 1).

Farmers often use family labor for farm work, but hired labor is also important in the study area. Family labor is not a cash expenditure from the farmer's perspective, and it is complicated to identify the amount of family labor contributed to each cultivation system, as farmers have different household size and labor availability. Therefore, all calculations were conducted based on the total amount of labor per day required for each cultivation system. The costs of seeds, saplings, irrigation, pesticides and fertilizers are calculated based on the amount used for each cultivation system.

Table 1: Yearly cash flow of selected cultivation systems in the research sites (US$/ha).

	Type of crop	Year	Cost	Revenue	Profit
Indonesia	Upland rice	1-30	217.10	1,500.00	1,282.90
	Maize	1-30	286.10	1,500.00	1,213.90
	Yam	1-30	268.60	1,800.00	1,531.40
	Cassava	1-30	365.60	1,500.00	1,134.40
	Peanut	1-30	308.60	1,500.00	1,191.40
	Soybean	1-30	145.00	445.00	300.00
	Durian	1	113.67	0.00	-113.67
		2-3	26.17	0.00	-26.17
		4-6	38.17*	220.00*	181.83
		7-8	44.17*	410.00**	365.83
		9-30	50.17*	1,100.00***	1,049.83
	Nutmeg	1	214.17	0.00	-214.17
		2-6	131.67	0.00	-131.67
		7-9	143.67*	200.00*	56.33

[27] Macdicken K. G., Vergara N.T., (1990). *Agroforestry: Classification and Management.* John Wiley & Sons, New York.

		10-12	173.67*	320.00**	146.33
		13-30	203.67*	560.00***	356.33
	Teak	1	360.00**	0.00	-360.00
		2-9, 12-19,22-29	12.00	0.00	-12.00
		10,20,30	111.98*	30,000.00	29,888.02
		11,21	300.00**	0.00	-300.00
Bangladesh	Upland rice	1-30	170.00	1,310.00	1,140.00
	Maize	1-30	195.00	1,715.00	1,520.00
	Sesame	1-30	160.00	1,062.50	902.50
	Turmeric	1-30	635.00	3,057.50	2,422.50
	Cucumber	1-30	261.00	2,327.25	2,066.25
	Banana	1-30	792.00	6,967.00	6,175.00
	Mango	1	150.00	0.00	-150.00
		2-5	17.31	0.00	-17.31
		6-8	30.00*	1,360.00*	1,330.00
		9-11	70.00*	3,157.52**	3,087.52
		12-30	95.00*	5,320.00***	5,225.00
	Jackfruit	1	130.00	0.00	-130.00
		2-5	16.50	0.00	-16.50
		6-7	25.00*	858.33*	833.33
		8-9	50.00*	1,716.67**	1,666.67
		10-30	70.00*	2,570.00***	2,500.00
	Lychee	1	140.00	0.00	-140.00
		2-5	16.50	0.00	-16.50
		6-8	35.00*	1,188.84*	1,153.84
		9-11	90.00*	3,423.33**	3,333.33
		12-30	115.00*	4,730.38***	4,615.38
	Mangium	1	130.00**	0.00	-130.00
		2-9, 12-19,22-29	12.50	0.00	-12.50
		10,20,30	100.00*	6,600.00	6,500.00
		11,21	130.00**	0.00	-130.00

* Additional labor cost for fruit/timber harvesting; ** additional cost for saplings.
* Low production; ** medium production; *** high production.