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Household opportunity costs of protecting and developing forest lands in Son La and Hoa Binh Provinces, Vietnam

Le Ngoc Lan
International Center for Tropical Agriculture (CIAT), Asia Office, Hanoi, Vietnam
l.le@cgiar.org

Dennis Wichelns
Stockholm Environment Institute (SEI), Asia Centre, Bangkok, Thailand
dwichelns@csufresno.edu

Florence Milan
International Water Management Institute (IWMI), Southeast Asia Office, Vientiane, Lao PDR
milanfmp@gmail.com

Chu Thai Hoanh
International Water Management Institute (IWMI), Southeast Asia Office, Vientiane, Lao PDR
c.t.hoanh@cgiar.org

Nguyen Duy Phuong
Soil and Fertilizer Research Institute (SFRI), Hanoi, Vietnam
ndpptn@yahoo.com

Abstract: Vietnam has pilot-tested a payment for forest environmental services (PFES) program in an effort to restore and protect forest areas, some of which have been severely degraded by the excessive cutting of trees by small-scale farmers planting annual crops on steep, sloping lands. The pilot program implemented in southern Vietnam seems to be successful, yet the program in northern Vietnam has not produced the desired rates of planting and maintaining forest areas. The reasons for these mixed results include differences in socio-economic characteristics and also the production and marketing opportunities available to rural households in the project areas. To gain insight regarding program participation, we examine the household-level opportunity costs of planting and maintaining small

plots of forest trees in northern Vietnam. We find that small-scale farmers in Hoa Binh Province, with limited financial resources, prefer the annual revenue stream provided by crops such as maize and cassava, rather than waiting for 7 years to obtain revenue from a forest planting. Farmers in Son La Province, with limited access to markets, prefer annual crops because they are not able to sell bamboo shoots and other forest products harvested from their small plots. In both provinces, the payments offered for planting and maintaining forest trees are smaller than the opportunity costs of planting and harvesting annual crops. Thus, most households likely would choose not to participate in the PFES program, at current payment rates, if given the opportunity to decline.

Keywords: Bamboo, cassava, feasibility, maize, payment rate, PES, PFES, smallholders

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1. Introduction

Forest degradation impairs the quality of forest ecosystem services, which include watershed protection, biodiversity conservation, tourism, carbon sequestration, and landscape beauty (Briner et al. 2013; Muhamad et al. 2013, 2014; Barber et al. 2014; Balthazar et al. 2015). Interest has increased in recent years in reducing forest degradation and restoring ecosystem services, particularly in upland areas where soil erosion due to degradation can be severe (Edwards et al. 2014a,b; Tadesse et al. 2014a,b; Vu et al. 2014). Programs that promote the payment for ecosystem services in forested areas have been implemented in several countries (Wunder 2008; McElwee 2012; Suhardiman et al. 2013; Huong et al. 2014; McElwee et al. 2014). Such programs link beneficiaries (those who pay for the services) with farmers and other users of natural resources (the providers of the services) through systems of conditional payments (Wunder 2005; Wertz-Kanounnikoff and Rankine 2008).

Payments for ecosystem services (PES) are considered to be voluntary transactions in which a well-defined environmental service is purchased by at least one buyer from at least one provider, if and only if, the environmental service provision is secured (Wunder 2005, 2008; Wunder et al. 2005). The notion of conditionality is reflected in the second half of the definition. The service must actually be provided for the program to be considered successful. In settings with well-defined property rights and low transaction costs, PES programs have the

potential to be more successful than command-and-control approaches in reducing environmental degradation in upland areas of lower income countries (Neef and Thomas 2009). However, some degree of government intervention, such as regulations limiting the allowable amount of pollution, is required in many cases to facilitate successful payment programs (Vatn 2015). In addition, PES programs might not succeed in areas with insecure property rights, where smallholders have limited trust in public officials, or where the capacity to monitor and enforce land use regulations is inadequate (George et al. 2009).

In theory, PES programs are sustainable and efficient (Pagiola and Platais 2007; Pagiola et al. 2007). Sustainability is assured by the mutual self-interest of service users and providers. Each group has an incentive to engage in resource protection, without the need of financial support from governments or donors. PES is efficient because "it conserves services whose benefits exceed the cost of providing them, and does not conserve services when the opposite is true (Pagiola et al. 2007)." In other words, if the providers (forest owners) receive a benefit that is greater than the alternative benefit obtained through deforestation, they would choose to conserve the forest, rather than destroying it. Some authors suggest that PES programs must be both efficient and fair, to achieve environmental and livelihood improvement objectives, particularly in lower income countries (Leimona et al. 2015). The degree to which a PES program achieves its goals is due largely to program design, implementation, and the socioeconomic characteristics of buyers and sellers (Engel et al. 2008; Sangkapitux et al. 2009).

Potential problems with PES programs include the possibility of creating poverty traps in which households in lower income communities become dependent on the payments and, thus, lose their incentive to innovate or to invest in activities that would generate economic growth (Karsenty 2007). Communities and regions also might become reliant on payments, to the extent that local or national economies become distorted by an excessive focus on PES programs. Kronenberg and Hubacek (2013) characterize this possibility as an "ecosystem service curse" in a fashion that is similar to the well-known resource curse or "Dutch disease" that arises when a country specializes in the production and export of an extractive commodity, such as oil or minerals, to the detriment of other productive sectors (Corden and Neary 1982; Apergis et al. 2014). PES programs also can stimulate rent seeking and other forms of strategic behavior by individuals or communities endeavoring to increase their receipt of program expenditures (Salzman 2005; Kronenberg and Hubacek 2013). The likelihood of encountering an ecosystem service curse, stimulating rent seeking behavior, or creating a poverty trap can be reduced by strengthening institutions, such as community or village councils and providing secure property rights to land, water, and forest resources (Vatn 2010; Dougill et al. 2012; Kronenberg and Hubacek 2013; Alix-Garcia and Wolff 2014; Barbier and Tesfaw 2014; Lambini and Nguyen 2014; Pham et al. 2014; Pinyopusarerk et al. 2014).

2. Paying for ecosystem services in Vietnam

2.1. Setting and background

Vietnam is the leading country in Asia, with regard to PES implementation. The country implemented its flagship program, payment for forest environmental services (PFES), in Lam Dong and Son La Provinces in 2008 (To et al. 2012). After studying the results of pilot programs, the Vietnamese government developed policies and guidelines in support of implementing PFES across the country. As defined in Government Decree 99, the forest environmental service buyers include companies engaged in hydropower, water supply, and tourism (Kolinjivadi and Sunderland 2012).

Direct payments between buyers (companies) and providers (forest owners) are encouraged in Vietnam, yet the transactions require government intervention in the form of forest protection and development funds (FPDFs) at national and provincial levels. These funds collect revenue from hydropower generators [20 Vietnamese Dong (VND) per kWh, which is about $0.001 per kWh], water supply companies (40 VND per m^3 of clean water produced), and tourism companies (1%–2% of revenue generated in the payment period). In the course of paying for ecosystem services, the fund is distributed to forest owners, which include individual households, communities, and forest enterprises (Winrock 2011; McElwee et al. 2014). The payment rate per hectare of forest varies across provinces, with differences in watershed conditions and the types and quality of forest lands.

The PFES program in Vietnam has been implemented in conjunction with the larger effort of devolving responsibility for forest management from the central government to communities and individuals (Clement and Amezaga 2009). Beginning in the 1990s, individuals have been given 50-year leases to forest lands, along with the right to exchange, transfer, and inherit the lands they manage (Sikor and Nguyen 2007; Nguyen 2008). Not all of the forest lands are forested, as substantial deforestation had occurred during the 1940s through the 1980s (Nguyen et al. 2010). One goal of the devolution program is to encourage communities and households to invest in reforestation of degraded areas, with the intent also of alleviating poverty in rural and upland areas (Sikor and Baggio 2014).

2.2. Many small holdings and low payment rates

PFES implementation can have positive or negative impacts on forestry development and protection, depending on the natural conditions and characteristics of a given province. For instance, Lam Dong Province has experienced significant achievements in forestry management. Households in Lam Dong have relatively large landholdings and, thus, receive substantial PFES payments for maintaining and expanding the forest (McElwee et al. 2014). By contrast, the average household landholding in Son La Province (about 2 ha) is too small to generate sufficient income to persuade farmers to conserve or expand the forested area (To et al. 2012).

The potential returns from crop production also complicate efforts to persuade households to maintain or expand forested areas that could alternatively

be planted in maize, cassava, or bamboo (Nguyen et al. 2010). Indeed, household-level opportunity costs and insecure land tenure often are cited as responsible for the limited success of the PFES program and other conservation efforts in some areas of Vietnam and other countries (Wunder 2008; Affholder et al. 2010, McElwee 2012; Jourdain et al. 2014). Agriculture is the primary source of income in rural areas of Vietnam, and many households in upland areas have experience in crop production for subsistence or for sale in nearby markets (Jourdain et al. 2009). The household-level benefits from crop production generally are larger than those available from protecting forest resources, particularly in the near term.

Efforts to maintain or expand forest areas require that households delay the profits they might receive from producing crops on open lands or selling timber from forested lands. These forgone benefits, or opportunity costs, can impair the performance of a program designed to secure the voluntary provision of ecosystem services (Stephenson 2012). In a review of 29 PES programs implemented in tropical and sub-tropical countries, Calvet-Mir et al. (2015) find that program effectiveness is increased when payments exceed local opportunity costs. Effectiveness increases also with the length of time during which the payments are provided. Démurger and Pelletier (2015) describe the role of opportunity costs in household decisions to participate in China's Sloping Land Conversion Program. Plots located far from an asphalt road, and lands with greater slope, are more likely to be enrolled.

The current payment rate for protecting forest ecosystems in Vietnam is based on the value of forest in providing water conservation and erosion control (Winrock 2011), while not considering the opportunity cost of current land uses. This likely is one reason that Vietnam's PFES program has not been fully effective in some areas (de Jong et al. 2006). Wertz-Kanounnikoff and Rankine (2008) suggest that inadequate payments limited the effectiveness of the original reforestation incentive programs in Vietnam (Programs 327 and 661). The average incentive payment was about VND 50,000 (about USD 2.40) per ha per year, while the net returns to maize, rice, and cassava cultivation were in the range of VND 1–3 million (about USD 48–142) per ha per year. In some upland and mountainous provinces, budget constraints limited the incentive payments to VND 25,000–VND 30,000 per ha per year. Thus, the annual incentive payments generally were less than 5% of the opportunity cost of producing maize, rice, or cassava.

The small size of household plots limits the success of incentive programs pertaining to forest resources across Vietnam. Of the 1.4 million households that had been awarded some form of property rights to forest lands by 2006, 800,000 households (57%) controlled less than one hectare, while 500,000 households (36%) managed from 1 to 5 hectares (McElwee 2012). It is not possible for such households to sustain livelihoods with only the small payments they receive for protecting or extending forest areas. They must also produce crops or engage in the harvest of non-timber forest products (NTFPs) for home consumption or for sale in local markets.

2.3. Protection, production, and special-use forest lands

The Vietnamese Law on Forest Protection and Development (1991) defines three categories of forest and forestry lands, according to intended land uses (Wertz-Kanounnikoff and Rankine 2008; Clement and Amezaga 2009):

1. Special-use forest and forestry land intended for use in nature conservation and landscape protection. These forests are managed primarily as national parks, nature reserves, and cultural, historic, and environmental sites.
2. Protection forest and forestry land intended for uses that include regulating water resources and protecting soils. Anti-erosion and anti-desertification programs are implemented on these lands, with the additional goals of regulating the climate and maintaining ecological and environmental security.
3. Production forest and forestry land intended for commercial activities that include the harvest of timber and NTFPs.

The first two categories are largely protected areas that are managed by the government or by State Forest Enterprises (SFEs). The third category includes the land allocated to communities and individuals for forest production activities. The distinction between forest and forestry land reflects the intended use of some lands that are not yet forested, but will be part of an afforestation program (Clement and Amezaga 2009).

2.4. Examining opportunity costs

Our goal in this paper is to describe the household-level opportunity costs of participating in the PFES program in two provinces in northern Vietnam. To this end, we examine the potential net returns from crop production, and from harvesting and selling forest products, and the payments offered to households participating in the PFES program. In one case, we compare the potential returns from crop production with the potential returns from maintaining a production forest. In a second case, we compare the potential returns from crop production with the PFES payments received for maintaining a protection forest, from which no products are harvested for sale. Our results should contribute to the design of more effective PFES programs in Vietnam and elsewhere.

3. Methodology

3.1. Study sites

We conducted our study in Da Bac District, Hoa Binh Province, and in Moc Chau District, Son La Province in northern Vietnam (Figure 1). Both of these mountainous provinces are located within the Da River watershed, and both participate in

Figure 1: Hoa Binh and Son La Provinces, in northern Vietnam.

the PFES Program. The two largest purchasers of environmental services in Hoa Binh and Son La Provinces are hydropower companies that provide a substantial portion of PFES program funding. The Hoa Binh Hydroelectric Plant, completed in 1994, has a capacity of 1920 MW and generates about 9 billion kWh of electricity annually. The Son La Hydroelectric Plant, completed in 2014, has a capacity of 2400 MW and also generates about 9 billion kWh annually (Nguyen et al. 2013).

We selected the districts of Da Bac and Moc Chau because both are located in upstream areas of the Hoa Binh Reservoir. Da Bac is the largest district in Hoa Binh Province, with a total area of 779 km². The population of the district is about 53,000, and is comprised largely of four ethnic groups, the Tay (42%), Muong (26%), Dao (14%) and Kinh (12%) (Manasboonphempool and Zeller 2014). Moc Chau District in southwestern Son La Province, has a total area of 1081 km² and a population of 104,703 (2013). The largest ethnic groups are Thai (33%), Muong (18%) and Kinh (15%).

As in other mountainous regions of Vietnam, economic activities in Da Bac consist largely of agriculture and forestry. However, compared to other regions, forest production is prominent in the Da Bac, due to the strong forest development strategy of Hoa Binh Province. Prior to PFES implementation, the district had achieved notable outcomes in other national forestry initiatives (Programs 327, 661, and 747), with considerable expansion in the area allocated to forest production (Do 1998). Even after those programs ended, farmers continued to invest in forest production activities. At present, about 33% of the forest area in Da Bac District is enrolled in the PFES forest protection program, while 28% of the forest area is engaged in production. Thus, even though forest owners participating in the PFES program receive only VND 65,000 per ha per year (about USD 3 per ha per year), the program seems to have potential in Da Bac District.

Given the considerable expansion of forest production activities, we estimate the opportunity cost of forest production in Da Bac, rather than that of forest protection. Thus, we compare the potential household-level returns from planting trees and harvesting forest products with the potential returns from producing crops. We do not evaluate the option of receiving payments for forest protection in Da Bac. However, the potential return from acacia or bamboo production, or the potential return from maize production, can be viewed as an opportunity cost to forest protection.

The primary sources of income in Moc Chau are agriculture, dairy production, and tourism. Forestry in Moc Chau is much less developed than in Da Bac. Forestry related activities in the district focus on protection rather than production. There are few buyers of forest products in Moc Chau, as the distance to markets and the associated transport costs are substantial.

The Government of Vietnam chose Son La Province for pilot implementation of the PFES program. The payment rate applied in Son La Province is VND 220,000 per hectare, per year (about USD 10), which is higher than the rate in Hoa Binh Province. However, many farmers in Son La Province and in Moc Chau District, in particular, seem uninterested in expanding the forest. Thus, we examine the opportunity cost of forest protection in Moc Chau, rather than that of forest production. In particular, we compare the potential returns from crop production with the payments received, alternatively, for protecting the forest.

3.2. Data collection

We obtained primary data using unstructured interviews and focus group discussions with local officials and farmers in Da Bac and Moc Chau Districts. The local officials include staff members from the Department of Agricultural and Rural Development (DARD), SFEs, forestry limited companies, and the FPDF. We selected 60 households in each district, choosing at random from a list of all households. When conducting the survey, only 45 households were available in Da Bac, while 48 households were available in Moc Chau. Thus, our complete sample contains information from 93 households. The average age of respondents

is somewhat higher in Moc Chau, where households are larger and better educated (Table 1). The average forest production area is smaller in Moc Chau, yet households there also maintain plots of forest for protection. In Da Bac, the protection forest is allocated to villages, rather than households. The average area in maize production is 0.7 ha in Da Bac and 1.1 ha in Moc Chau (Table 1).

We conducted focus group discussions in each village to validate the information we collected during the household interviews. We obtained information describing forest production activities in interviews with officials from SFEs, forestry rangers, and the forestry limited company. Additional data sources include the district statistical departments, district annual reports of agriculture and forestry, the forest investment norms of the SFEs and forestry limited companies, and the forest harvest reports prepared by the forestry rangers in each district. From these sources, we obtained secondary data, including time series information describing revenues, crop yields, timber logging, wood harvest, and the harvest of NTFPs.

4. Scenario analysis

4.1. The present value of net revenue

We estimate the opportunity cost of land use in financial terms, which is the present value of net revenue that can be earned in an alternative activity. Thus, we examine the potential stream of net revenues before and after a parcel of land is converted to forest use. Revenue is earned from the sale of timber, in the case of forestry, or the sale of crops, if the land is used for crop production. Total costs include expenditures for seeds, fertilizer, pesticides, herbicides, and labor. We gathered data describing the total cost and revenue of maize production from households in both Da Bac and Moc Chau. The reported input costs are somewhat

Table 1: Summary statistics describing households interviewed in the Da Bac and Moc Chau Districts in Hoa Binh and Son La Provinces, Vietnam.

Variable	Da Bac (Hoa Binh)		Moc Chau (Son La)	
	Range	Mean, S.D.	Range	Mean, S.D.
Number of households	45		48	
Age of respondents (years)	20–60	40, 14.1	25–75	45, 12.6
Household size (persons)	1–7	4.1, 1.3	1–7	4.7, 1.5
Household education (scale)*	1–6	2.2, 0.8	1–6	2.7, 1.3
Active labor (persons)	1–5	2.4, 0.8	1–4	2.4, 0.8
Production forest (ha)	0.1–4	0.8, 0.9	0–0.6	0.02, 0.97
Protection forest (ha)**	n.a.	n.a.	0–8	1.2, 2.2
Maize production (ha)	0.04–2.3	0.7, 0.5	0–4	1.1, 1.1

*Education levels: 1=no school, 2=elementary school, 3=secondary school, 4=high school, 5=college, 6=university.

**The forest protection area in Da Bac (Hoa Binh) is allocated to villages, rather than to households.

higher in Da Bac, while the average reported revenues are somewhat smaller (Table 2). Thus, the reported average net return to maize production is notably smaller in Da Bac (USD 356 per ha) than in Moc Chau (USD 881 per ha).

The most prominent tree for forest production in Hoa Binh Province is acacia, which has a 7-year production cycle. Thus, we calculate the Net Present Value in Da Bac District over a 7-year time horizon. We estimate the costs and revenues of acacia production from establishment to harvest, and we compare these to the annual costs and revenues of crops that might be produced during the same 7 years. Data describing the costs and returns from acacia production, interplanted with cassava, were obtained from farmers with experience in this production activity. The average initial establishment cost for acacia is USD 506 per ha (Table 3). The additional establishment cost, in year 2, is USD 218 per ha. The interplanted cassava generates USD 298 in revenue during years 1, 2, and 3, while the acacia harvest in year 7 generates a revenue of USD 2400 per ha (Table 3).

We calculate the present value sum of net revenue (NPV) as follows:

$$\mathrm{NPV}=\sum_{t=0}^{t=n}\frac{R_t-C_t}{(1+i)^t}$$

where: R_t is revenue in year t, C_t is cost in year t, t is the year and i is the discount rate. When the estimated NPV is positive, the investment in the land use activity is considered profitable. When the estimated Net Present Value is less than or equal to zero, the investment does not generate a profit and, thus, the land owner should shift his or her investment to a different land use. We calculate the sum of net revenue using two discount rates provided by the Vietnam Bank for Social Policies (VBSP). The Bank uses the rate of 6.5% for loans to poor households, while it uses the rate of 9% for production loans. We chose VBSP rates, given the popularity of VBSP lending activities in rural areas.

Table 2: Summary statistics describing the costs and returns of maize production, as reported by households interviewed in the Da Bac and Moc Chau Districts in Hoa Binh and Son La Provinces, Vietnam.

Variable	Da Bac (Hoa Binh)		Moc Chau (Son La)	
	Range	Mean, S.D.	Range	Mean, S.D.
Number of households	45		48	
Input costs (USD per ha)*	150–1890	697, 414	143–762	326, 215
Revenue (USD per ha)	429–2700	1053, 653	442–4000	1207, 1326
Net returns (USD per ha)**	128–2136	356, 150	143–3238	881, 620

*Inputs include fertilizer, seeds, pesticides, hired labor, and transportation.
**The median values of net returns for maize, which we use in our economic analysis, are USD 353 per ha in Da Bac and USD 964 per ha in Moc Chau.
Source: These data were obtained from households producing maize in Da Bac and Moc Chau.

Table 3: Summary statistics describing the costs and returns of acacia production, inter-planted with cassava, as reported by households interviewed in the Da Bac District in Hoa Binh Province, Vietnam.

Year	Items	Cost of inputs	Total revenue	Net revenue
1	Initial establishment: acacia seedlings, cassava stalks, hired labor, fertilizer pesticides, transportation. Revenue from the sale of cassava	506	298	–208
2	Additional establishment: acacia seedlings, cassava stalks, hired labor, fertilizer pesticides, transportation. Revenue from the sale of cassava	218	298	80
3	Maintenance: cassava stalks, hired labor, fertilizer, pesticides, transportation. Revenue from the sale of cassava	88	298	210
4–6	Maintenance: hired labor for cultivation, pruning, and weeding	30	0	–30
7	Timber sale: the costs of harvest and transport are deducted from the sale price of the timber		2400	2400

Note: Acacia trees are planted in year 1 and harvested in year 7. Cassava is planted between the trees in year 1 and harvested in years 1–3.
Source: These data represent the average values reported by seven farmers with experience in producing acacia and cassava in Hoa Binh Province.

4.2. The opportunity cost of forest production in Da Bac

Da Bac District has a diversified cropping system that includes paddy rice, upland rice, maize, cassava, rice, arrowroot, and sugarcane. Maize and cassava accounted for 40% and 28% of the cultivated area in Da Bac in 2012, respectively, while rice and arrowroot accounted for 15% and 9%, respectively. Thus, maize and cassava production are prominent activities and they provide notable employment in the District. Nearly all of the households we interviewed (90%) cultivate at least one plot of maize or cassava, because the crops are traditional, they are easy to grow, and they provide a good yield. Most of the harvested maize and cassava is sold, while some is saved for seeds in the next season, and some is fed to livestock.

The total area of paddy rice and upland rice in Da Bac is about 1200 ha, or 15% of the cultivated area. Rice is produced only for household consumption. However, the amount of rice produced normally is not enough for family consumption, due to the lack of land available for paddy production, the large numbers of household members, and the low to moderate yields. To increase crop yields, and in the interest of utilizing all land, farmers in Da Bac have engaged in crop rotations similar to those found in other northern upland regions of Vietnam (Table 4). Some farmers also have engaged in aquaculture, with an interest in diversifying their production activities and consumption opportunities.

Agricultural production in Da Bac has changed somewhat in recent years. The cultivated area has declined from more than 10,000 ha in 2008 to about 7000 ha in 2012, due largely to population growth, which has caused the conversion of land

Table 4: Current land uses and cropping patterns in Da Bac District, northern Vietnam.

Crop specialization	Cropping patterns observed
1. Rice	Upland rice
	One or two crops of paddy rice per year
2. Maize and short-season industrial crops	One or two crops of maize per year
	One crop of cassava or sugarcane per year
	Two crops of peanuts or soybeans per year
3. Mixed crops and crop rotations	One crop of rice, plus one short-season crop
	One crop of rice, plus two short-season crops
4. Perennial crops	Acacia, bamboo, eucalyptus, or mo (*Manglietia conifera*)

from agricultural to residential and commercial uses. As a result, the areas planted in maize, cassava, and other crops have declined over time (SRD 2010).

The area planted in maize has declined by about 30% in recent years, falling from about 6000 ha in 2006 to about 4000 ha in 2012 (Figure 2). Rice cultivation has declined by about 1000 ha during that time, causing concern among farmers regarding their efforts to achieve and sustain household food security. The areas planted in cassava and arrowroot have increased over time, while the area planted in sugarcane has remained largely the same in recent years (Figure 2).

The changes in planted areas have contributed to notable changes in crop production since 2006 (Figure 3). The increasing amounts of cassava and arrowroot produced each year are the result of increases in planted areas. Similarly, the production of maize and rice has declined, due partly to the decline in planted areas. Although the area planted in maize has declined in recent years, with changes in farmer preferences, maize remains the primary crop in the district, with the largest cultivated area. We therefore consider the potential net returns from maize production to represent the opportunity cost of forest production in Da Bac District.

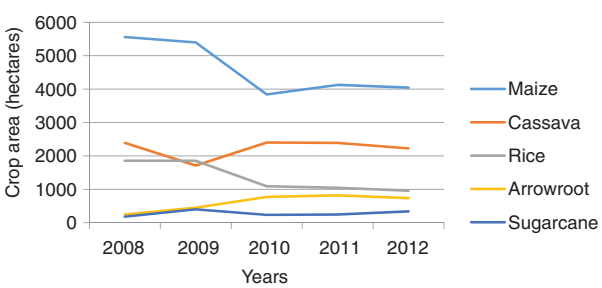

Figure 2: Areas in primary crops in Da Bac District, Hoa Binh Province, Vietnam, 2008–2012.
Source: Da Bac District annual agricultural production reports.

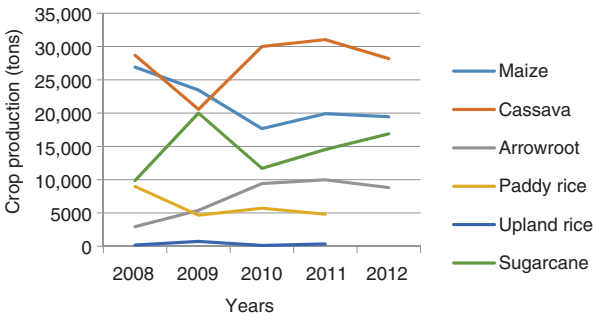

Figure 3: Production of primary crops in Da Bac District, Hoa Binh Province, Vietnam, 2008–2012.
Source: Da Bac District annual agricultural production reports.

4.2.1. Forest management activities

All three types of forest and forestry land (production, protection, and special-use) are found in Da Bac District, which has a history of good performance in forestry management activities. This has contributed to a large expansion in forested area and a declining amount of illegal logging activity. Having expanded by more than 5000 ha in recent years, at an average rate of about 1376 ha per year, forest areas now account for two-thirds of the area of the district (Clement and Amezaga 2009). The total area of forest rehabilitation is about 32,717 ha, which is more than 50% of the current forest cover.

The expansion of forest area in Da Bac District is due largely to support from government programs and local authorities. Among those efforts, Program 661 or the "Five Million Hectare Reforestation Program," supported by the government, is perhaps the most popular, and it has attracted the participation of many households. The program provided seedlings to households and compensated households for their labor, upon certification of forest quality. When the production cycle of the trees is complete, households may harvest the timber for sale to traders or to local SFEs. Most of the seedlings provided by the program were bamboo and acacia.

Following completion of the government program, many farmers in Da Bac have continued to invest in acacia plantations on their own, given the success they had achieved in earlier years. Recently, the acacia harvest was lost in many areas of the district, due to cold weather. As a result, some households have attempted to produce other trees, such as the Benzoin tree and eucalyptus. The households suggest these trees might generate higher benefits and are better suited for the local climate. Benzoin and eucalyptus have not yet established a production record in the region and, thus, we do not include them in our analysis. Rather, we estimate the net returns from acacia production, interplanted with cassava, during a 7 year production cycle.

Table 5: Median values of the estimated annual costs and revenue of maize production, as reported in a survey of households in Da Bac District, 2013.

Maize production inputs	USD per ha
Maize seed	95.90
Fertilizer	399.60
Pesticides, including herbicides	73.40
Agricultural labor	522.70
Total costs	1091.60
Total revenue	1445.00
Net revenue (per ha)	353.40

4.2.2. The opportunity cost of forest production

We estimate the net returns of maize production, using data describing input costs and revenue collected during our survey of farm households in Da Bac (Table 5). When comparing the net present values of maize and acacia production over 7 years, we consider that the net revenue of maize production will vary annually, due to differences in weather, planting success, cultural practices, insects, diseases, competition from weeds, and random shocks. We simulate the potential variation in the net revenue of maize, for cases of high and low variation, using a random number generator. The high and low variability scenarios are the following:

(1) High Variability: Maize net revenue varies at random within the range of 0.5–1.5 times the median value of net revenue reported in 2013 (Figure 4).
(2) Low Variability: Maize net revenue varies at random within the range of 0.5–1.25 times the median value of net revenue reported in 2013 (Figure 4).

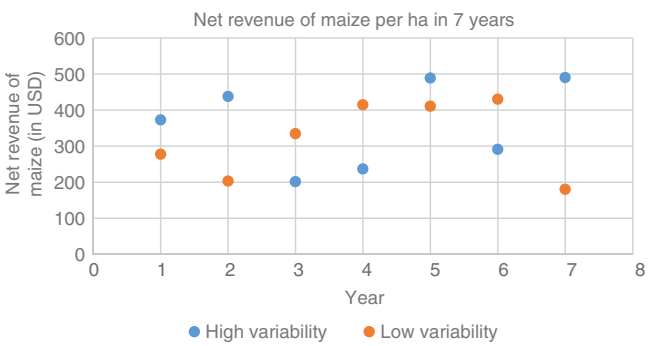

Figure 4: Simulated net revenues of maize during 7 years, with high variability and low variability imposed using a random number generator, in US Dollars per hectare.
Source: Authors' calculations.
The median calculated value of net revenue is USD 353.40 per ha (Table 2).

In particular, we derive the series of seven annual net revenues in each scenario, as follows:

$$NR\ (t) = NR\ (m) * Sigma$$

where: NR (t)=The simulated net revenue for maize in year t, for t=1,… 7.
NR (m)=The median calculated value of net revenue, obtained in our 2013 household survey, which is USD 353.40 per ha (Table 5).
Sigma=a randomly generated number, between 0.5 and 1.5 in the High Variability Scenario, and between 0.5 and 1.25 in the low variability scenario.

We estimate the net present value of acacia production, beginning with the establishment cost in 2007 and continuing through harvest in 2013 (Table 6). During the first 3 years of establishment, many forest owners plant a secondary crop, such as cassava, to earn some revenue from the available land, before the trees become large. We consider the net returns from cassava in our estimate of the net present value of acacia production (Table 6). From the fourth year until harvest, forest owners invest five person-days per year for protecting and maintaining the trees. Thus, the net revenue during the last 3 years before timber harvest is negative.

4.3. The opportunity cost of forest protection in Moc Chau

Maize and coffee are the most prominent crops in Son La Province. In Moc Chau District, maize accounts for most of the cultivated area, while the areas planted in other crops are not substantial (Figure 5). Fruit trees, including plums and peaches, also are planted in the district. Land uses in the district include four categories (Toan 2013), which are similar to those in Da Bac District (Table 7).

The climate and soils in Moc Chau favor maize production, and the net revenue from maize accounts for a large portion of household income. The area

Table 6: Estimated annual costs and revenue of acacia production, in Vietnamese Dong and US Dollars, per hectare.

Year	Annual cost (VND 1000)	Cassava revenue (VND 1000)	Total revenue (VND 1000)	Net revenue (VND 1000)	Net revenue (US Dollars)
Year 1	10,622	6250	6250	–4372	–208
Year 2	4569	6250	6250	1680	80
Year 3	1856	6250	6250	4394	210
Year 4	640	0	0	–640	–30
Year 5	640	0	0	–640	–30
Year 6	640	0	0	–640	–30
Year 7	0		50,000	50,000	2400

Source: Authors' calculations.
The acacia timber is harvested in year 7. Harvest labor is provided by the purchasers of the timber, and the labor cost is deducted from the total revenue paid to the farmer.
Currency conversion: 1 USD=21,000 VND, February 2014.

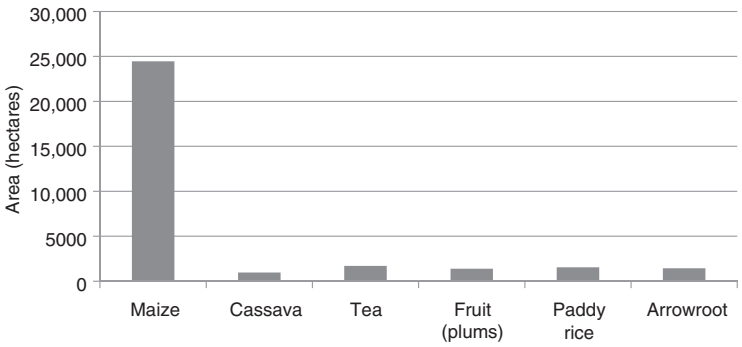

Figure 5: The cultivated area of major crops in Moc Chau District, 2012, in hectares. Source: Moc Chau statistical department.

Table 7. Current land uses and cropping patterns in Moc Chau District, northern Vietnam.

Crop specialization	Cropping patterns observed
1. Rice	Upland rice
	One or two crops of paddy rice per year
2. Maize and short-season industrial crops	One or two crops of maize per year
	One crop of cassava or sugarcane per year
	Two crops of peanuts or soybeans per year
	Two crops of sweet potatoes per year
3. Mixed crops and crop rotations	Maize in the spring, followed by rice in autumn
	Peanuts in the spring, followed by rice in autumn
	Soybeans in the spring, followed by rice in autumn
4. Perennial crops	Acacia, tea, or coffee
	Plums, peaches, mangoes, or oranges

planted in maize has remained largely constant in recent years, except for a slight increase in 2010. The areas planted in other crops have declined somewhat during 2006–2012 (Table 8). Total production of crops has changed somewhat during those years, while maize has accounted for most of the output and household income. The popularity of maize production limits household interest in forest management activities.

4.3.1. Forest management activities

There are three types of forest in Moc Chau: protected, special use, and production. However, forest production is not common in the district. The average annual increment in new forest plantations is only about 100 hectares (Moc Chau statistical department). The expansion is limited by the lack of local markets for forest products, high transportation costs, and the large profits available from maize production. In addition, the input costs for forest production largely exceed

Table 8: Changes in cultivated areas observed in recent years in the Moc Chau District of Son La Province Vietnam, in hectares.

Year	Maize	Cassava	Paddy rice	Tea	Fruit (plums)
2006	24,709	1168	5946	2705	1835
2007	24,108	2071	5657	2821	1819
2008	24,445	2074	5226	2873	1806
2009	24,605	1909	4934	2953	1817
2010	27,691	2072	4728	2962	1761
2011	24,287	1139	2550	1670	1378
2012	24,454	969	2700	1694	1378

Source: Moc Chau District statistical department.
The notable increase in maize cultivation in 2010 might be due to increases in maize prices and government support for expanding maize production in northern Vietnam (Saint-Macary et al. 2010). The notable decline in maize area in 2011 might be due to the severe drought that occurred during the pollination stage for maize in 2010 in Son La Province, which substantially reduced maize yields and household net incomes in that year (Tuan et al. 2014).

the revenue, thus resulting in small or negative net returns. In addition, due to the potentially high net revenue in maize production, many farmers remove forest trees to expand the area planted in maize. Given the challenging economics of forest production, Moc Chau District likely should focus on forest protection, rather than expanding the production forest, unless a more profitable opportunity becomes available.

Bamboo is the most widely planted tree in Moc Chau, as seedlings were provided in previous government programs. Recently, many districts in Son La province have been disallowing timber harvest from production or protection forests. This restriction does not apply in Moc Chau, which we have selected for analysis. A former SFE has become the Moc Chau Forestry Limited Company, which manages and harvests timber from the forest. The Company has provided much of the data we analyze in our study of forestry options in Moc Chau.

4.3.2. The opportunity cost of forest protection

We analyze the economics of protecting the existing forest. Thus, we do not consider the establishment cost when estimating the net benefits of forest protection. We estimate the net revenue of harvesting bamboo trees for sale, and selling bamboo shoots, using cost and harvest norms provided by the Moc Chau Forestry Limited Company. The potential annual net revenue from bamboo forest is higher than that for maize (USD 1038 v. USD 964 per ha, Figure 6). However, this net return from the forest can be generated only by the forest company, as individual households own only small areas of forest (about 1000 m²). In addition, households lack affordable access to a market outlet for bamboo products. The travel time from Hanoi to Moc Chau is 5–7 hours, by car, and many of the household plots are located quite far from a main road. Traders generally are not interested in purchasing bamboo products in Moc Chau, as the cost of transportation can

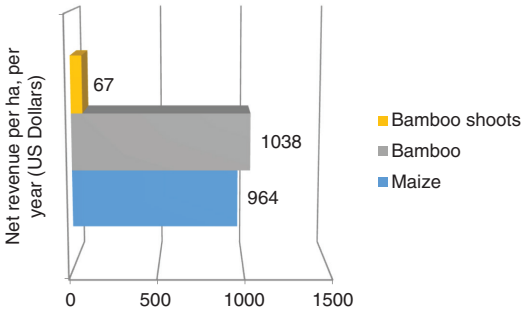

Figure 6: Median values of annual net revenue from bamboo forest and maize production in Moc Chau District, Son La Province.
Source: Household survey conducted in Moc Chau in 2013.

exceed the revenue. In many areas, bamboo shoots are a valuable NTFP. In Moc Chau, the bamboo produced on small household plots is used largely for family consumption.

5. Results

5.1. Da Bac District

We compare the net present values for acacia and maize production using the two discount rates, 6.5% and 9% (Table 9). In each case of high or low variability, the estimated net revenue from maize production is higher than the net present value earned from acacia production. The foregone financial benefit of choosing acacia production over maize production ranges from USD 221 to USD 500 per ha, over the course of a 7 year production cycle. The annualized net benefit of acacia

Table 9: Estimated net present values and equivalent annualized net benefits of acacia and maize production, over 7 years, in US Dollars per hectare.

	Discount rate	
	6.5%	9%
Net present values		
Acacia	1528	1293
Maize (high variability)	1958	1793
Maize (low variability)	1749	1599
Annualized net benefits		
Acacia	279	257
Maize (high variability)	357	356
Maize (low variability)	319	318

Source: Authors' calculations.

production is USD 279 per ha for the 6.5% discount rate and USD 257 per ha for the 9.0% discount rate (Table 9). The annualized net returns from maize production are higher, in both the low and high variability scenarios. The differences in annualized net benefits range from USD 40 to USD 78 for the 6.5% discount rate and from USD 61 to USD 99 per ha for the 9% discount rate (Table 9). Thus, a program payment of USD 99 per ha should be sufficient to encourage many households to forego maize production, in favor of planting and maintaining an acacia plantation, interplanted with cassava. A substantially higher annual payment, perhaps as large as USD 357 per ha (Table 9), might be needed to persuade households to forego both acacia and maize production, in favor of maintaining a protection forest.

The current payment rate of USD 3 per ha in Da Bac is not sufficient to motivate households to forego maize production. A substantially higher payment is needed. As noted above, hydropower generators contribute to the FPDF at the rate of 20 VND per kWh of electricity produced. The generating capacity of the Hoa Binh Hydroelectric Plant is 9 billion kWh per year. If all of that electricity were assessed at the rate of 20 VND per kWh, the Fund would receive 180 billion VND per year (USD 8.6 million). That amount would be sufficient to pay households at the rate of USD 99 per ha, to secure acacia production on about 87,000 ha. That area is larger than the current forest cover in Da Bac District (Clement and Amezaga 2009). Alternatively, the Fund would be sufficient to promote forest protection on about 24,000 ha, by offering households an annual payment of USD 357 per ha, to forego both acacia and maize production.

Our opportunity cost analysis does not account for any non-market contributions of PFES toward forest development. Yet, forest development of some sort might be viable in the region. In our survey, we posed several multiple choice questions to farmers, regarding environmental assessment, with the goal of examining the feasibility of forest production in Da Bac District. We asked farmers to assess the soil quality of their plots, and to describe their willingness to change land uses and their reasons for considering such change. About 90% of respondents stated that soil quality had degraded over time, leading to higher costs for fertilizer and, thus, lower profit.

The same proportion of respondents is willing to change from producing annual crops (maize) to growing forest trees. The farmers are particularly interested in the Benzoin tree *(Styrax Tonkinensis)*, as that tree is well suited for the cold winters of Da Bac District (Trinh Bao Son, forestry specialist, Cao Son Commune). Successful experiments with Benzoin tree plantations in the Cao Son Commune, located within the district, have motivated farmers to consider changing their current land uses. Timber sales from a Benzoin tree plantation can generate about VND 50 million per hectare (USD 2381), The estimated revenue from inter-cropping with annual crops is an additional USD 1429 per hectare (Table 10).

Given the interest in providing and sustaining ecosystem services, through investments in privately managed forests, it is helpful also to consider the

Table 10: Estimated annual costs and revenue of Benzoin tree production, in Vietnamese Dong and US Dollars per hectare.

Item	VND (1000)	US Dollars
Seeds	1500	71
Labor (Land prep and harvest)	12,000	571
Sum of costs	13,500	643
Revenue from timber sales	50,000	2381
Revenue from inter-cropping	30,000	1429

Source: Forestry specialist, Cao Son Commune, Da Bac District, 2013.
Inter-cropping activities include rice in year 1, followed by cassava in years 2 and 3. The timber is harvested in year 8.
Currency conversion: 1 USD=21,000 VND, February 2014.

differences in services provided by pure and mixed forest stands. Šálek and Sloup (2012) suggest that the planting of pure stands of trees, such as acacia, in conjunction with repeated burning, reduces biodiversity and degrades forest soils. In a case study involving pure and mixed stands in the central highlands of Vietnam, the authors show also that mixed stands generate higher household income, over time, than do pure stands of acacia (Šálek and Sloup 2012). McElwee (2009) examines the distributional impacts of reforestation efforts in Ha Tinh Province, Vietnam. The author finds that poorer households lose access to the NTFPs that sustain their livelihoods, when "bare hills" that actually contain many plant species are replaced by uniform plantings of a single cultivar. Thus, reforestation efforts and PES programs that promote mixed stands of trees might provide greater social, economic, and environmental benefits, than programs involving a single tree species.

5.2. Moc Chau District

The current payment level from the PFES program in Son La Province is USD 10 per ha per year, which is substantially smaller than the median reported value of net revenue from maize production (USD 964 per ha). Thus, the program likely will not be successful in protecting the forest. The government and policy makers should consider increasing the annual PFES payment to match the foregone net revenue from maize production, or assisting farm households in gaining affordable access to markets for their small harvests of timber and non-timber products. The latter strategy might be more affordable, given the substantial difference between the potential returns from maize production and the current PFES payments. The cost of enrolling 1000 ha at the annual rate of USD 964 per ha would be nearly USD 1 million per year.

As in Da Bac District, we asked farmers in Moc Chau to assess their soil quality and describe their willingness to change land uses. Seventy percent of respondents reported declining soil fertility. The remaining 30% suggested that

with higher investments of fertilizer, maize yields could be maintained. Farmers in Moc Chau expressed a desire to convert from maize to forest, but they lack information regarding suitable trees for Son La Province. Thus, they continue producing maize and other crops.

6. Conclusions

The net returns in maize production are about twice as large as those from acacia production in Da Bac District, Hoa Binh Province. In Moc Chau District, Son La Province, the net revenue for bamboo production is higher than that for maize production for the large forestry company. However, due to the small size of forest plots owned by individual households, and their lack of affordable access to markets, it is not possible for households to earn the same net revenue from bamboo production. The small PFES payments are not sufficient to encourage households to develop and maintain forest plantings. Nonetheless, as forest production can generate income for farmers in Da Bac, and while maize production leads to soil degradation, it might be more feasible to promote forest production in Da Bac than in Moc Chau, even though a higher PFES payment presently is available in Moc Chau.

Our results regarding the inadequacy of program payments to encourage smallholder investments in protecting or expanding forest areas complement those of other authors examining similar issues in Vietnam and elsewhere. About 10 years ago, Wunder et al. (2005) expressed concern regarding the small payments made available to farmers in Vietnam's Five Million Hectare Reforestation Program (McElwee 2012). Huong et al. (2014) and McElwee et al. (2014) confirm the significance of those small payments in their recent surveys of households participating in the program in Hoa Binh Province and Son La Province, respectively. Only 14% of the households interviewed by McElwee et al. (2014) report joining the program for the purpose of receiving annual payments. Twenty-four percent of the households report that they were required to participate. Nguyen et al. (2014) show that payments from the Vietnamese government to encourage reforestation with a native trees species (*Canarium album*) are not sufficient to compensate for the income foregone by farmers participating in the program.

The combination of small plot sizes and inadequate payments per hectare likely will continue limiting the success of programs designed to encourage forest protection and tree planting in Vietnam, particularly in upland areas with limited access to markets for timber and non-timber products. Higher payments per hectare, or other incentive programs, likely will be needed to achieve Vietnam's forest planting and protection objectives through voluntary initiatives. Program officials in other countries also might achieve greater success in sustaining protected areas if the annual payments are sufficient to offset the opportunity costs of participation and compliance.

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