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Exploring Environmental Services Incentive Policies for the Philippine Rice Sector: The Case of Intra-Species Agro Biodiversity Conservation*

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Abstract

This paper considers a hypothetical scheme of green payments to induce inter-specific agrobiodiversity in the context of Philippine rice farming. We empirically estimate a model of farmer behavior and then simulate the consequences of alternative (hypothetical) PES schemes under a fixed budget constraint. We find that, under this particular application, there is a clear trade-off between the two policy goals of enhancing biodiversity and poverty reduction. Even the totally untargeted lump-sum subsidy would have a larger poverty reduction impact than would the first-best conservation subsidy payment scheme. Therefore, policymakers would be required to strike a delicate balance between the two competing policy objectives. In addition, there is also a clear trade-off between the efficiency of targeted conservation payment and the information requirement for implementing subsidy schemes.

Key words: payments for environmental services (PES), biodiversity, conservation, poverty, rice, Philippines.

1. Introduction

There has been an increasing recognition that agriculture produces not only food and fibers but it also produces as joint products environmental services that are not traded in markets. These environmental services include climate regulation, carbon sequestration, waste absorption and breakdown, biodiversity and wildlife conservation, soil and water conservation and a host of others. The discussions surrounding those and other environmental services/externalities arising from agricultural production, however, appear to be markedly different in developed countries, on the one hand, and in developing countries, on the other. In

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the developed country contexts, including those in East Asia—Taiwan, Korea and Japan—, the emphasis tends to be on the positive externalities, while in developing countries the environmental concerns arising from agricultural production have often (if not exclusively) focused on negative externalities, such as the negative externalities arising from the use of chemical fertilizer and pesticides, environmental degradation due to upland cultivation, depletion of ground water due to pump irrigation, etc. (IRRI 2004).

In order to balance the relative lack of focus on positive externalities in the contexts of developing agriculture, we consider a hypothetical scheme of payments for environmental services (PES) to induce inter-specific agro-biodiversity in the Philippine rice farming. In the analyses of PES most of the existing studies focus on efficiency aspects of agricultural environmental services payments (see Kurlakova et. al. (2003); Feng, H. et. al. (2004); Feng, H. et. al. (2005); Lankowski, J. and M. Ollikainen (2003)). A review by Pagiola et. al. (2005), however, points to the possibility of synergies between poverty reduction and efficiency goals. They conclude that poverty impacts of these schemes depend on a number of technical and economic factors notably the population composition of target areas, targeting schemes, tenure security, and the size of the payments itself. In contrast, this study explores potential *trade-offs* between biodiversity conservation and poverty reduction goals. We attempt to quantify the magnitude of such trade-offs by empirically estimating a model of farmer behavior and then simulating the consequences of alternative (hypothetical) PES schemes under a fixed budget constraint.

Casual reference to the poverty impacts of PES schemes abound in the literature,[1] but there have been relatively few empirical studies that examine PES for agriculture and its poverty alleviation implications. The intent of this study is somewhat similar to Alix-Garcia et. al. (2004), who empirically addressed the conservation-poverty link in a different context, i.e.,

[1] See for instance the literature in PES for watershed management and biodiversity conservation. Wu, Zilberman, and Babcock (2001), on the other hand, is a good theoretical paper on the distributional consequences of different conservation targeting strategies.

that of PES for watershed management. Antle and Stoorvogel (2006), on the other hand, looked at agricultural "green subsidies" and poverty, but the focus is on carbon sequestration functions of agriculture. They used a simulation model to explore the potential impacts of payments for agricultural soil carbon sequestration on poverty and farm households and the sustainability of agricultural systems. They find support for the claim that carbon payment contracts provide sufficient incentives for farmers to shift to sustainable systems while reducing poverty.

Using a nationwide dataset from the Philippines, we focus on the farmer behavior of planting traditional rice varieties alongside modern rice varieties, and examine policy instruments that could potentially induce farmers to adopt this 'environmentally friendly technology.' This paper addresses three issues: (1) How much would it cost to induce rice farmers to plant traditional varieties, i.e. implementation cost of an intra-species conservation payments scheme?; (2) What would be the most effective form of payment scheme as an environmental policy instrument?; and (3) What are the poverty implications of these payment schemes? In addressing these issues, we pay particular attention to the potential trade-offs involved between the higher farm profit from *not* planting traditional rice varieties (since modern rice varieties tend to allow farmers to obtain higher profit through their higher yields) and the potential benefits of maintaining biodiversity in rice farming that may not be captured (entirely) by individual farmers. Such trade-offs could be particularly acute for relatively poorer farmers. From policymakers' point of view, the potentially efficient (optimal) policies for the goal of environmental preservation may not be fully consistent with poverty reduction goals. Such potential trade-offs from a policy making point of view is our major focus in the following analysis.

The rest of the paper is organized as follows. Before getting into our empirical analyses, in the next section we put into perspectives the sharp contrasts in the ways externalities arising from agricultural production are typically discussed in the developed versus the developing country contexts. Section 3 briefly introduces the issue of biodiversity conservation in the context of rice farming, in general, and the issue of traditional rice variety, in particular. Section 4 presents the empirical model to be used for the analysis. Section 5 is a short description of the dataset used. The next three sections present our results; section 6 presents our results on the determinants of the adoption of traditional variety cultivation, while section 7 discusses our results on the determinants of farm profit and the effects of traditional variety cultivation on farm profit. Section 8 presents the results of our policy simulations, with a focus on the impact of environmental service payment schemes on poverty outcomes. The final section concludes.

2. Contrasting Views on Externalities arising from Agricultural Production between Developed and Developing Countries

In order to understand the often-contrasting views about the externalities arising from agricultural production between developed and developing countries, it would be useful to recall the basic socioeconomic conditions in the rural areas of developed and developing counties, where three contrasting factors are particularly noteworthy; income level, the rate of population growth and socioeconomic structure of rural societies. First, the level of average income is vastly different between developed and developing countries. This has implications, for example, for the demand structures; as is well known since the discovery of the Engel's law, while food consumption occupies a large share of the total consumption bundle among low-income populations, the food share tends to decline and the demand for other goods and services increase as the income level rises, including the demand for clean water, clean air and other environmental amenities. Thus, the demand for environmental services is likely to be larger in developed countries than in developing countries. This observation is one factor giving rise to the notion of the "Environmental Kuznets curve" (e.g., Dasgupta et al. 2002).

The second crucial difference is the rate of population growth. In general, the population growth is relatively low in developed countries and relatively higher in developing countries. In particular, in rural areas of Japan the rate of population growth can often be negative, and the farming population (as well as the entire population) is rapidly aging. Younger generations in rural areas often tend to prefer non-agricultural occupations to farming, and one of the largest challenges for many farm households is to retain/find successors when the aging farmers retire. Thus, one of the main aspects of the so called 'multifunctionality' argument in Japan (as well as in other East Asian countries, such as Korea and Taiwan) is that abandoning of the lands that were previously farmed leads to either an increase in negative externalities or a decrease in positive externalities that had previously been provided when the land was under the care of the farmer. In contrast, however, the situation in most developing countries is quite different. There is a strong population pressure in rural areas of those countries, and in many places the previously uncultivated lands (including forest lands) are increasingly placed under agricultural purposes. Population pressure is one source of urban migration and such population movements, unlike in developed countries, do not usually lead to abandonment of previously farmed land.

This contrasting direction of population pressures (i.e., increasing population in developing countries versus decreasing population in developed countries) seems to be one source of the opposing views of agriculture as environmentally friendly or unfriendly. In developing country contexts, agricultural production is (quite rightly) regarded as a force of destroying environment (e.g., forest clearing for the purpose of crop production) while agricultural production is, quite rightly as well in their own contexts, often viewed as a protector of environment (e.g., a rice paddy providing larger amount of flood control function than would be provided by an abandoned land) in developed countries.

Finally, different social structures (village economies) in rural areas can give rise to contrasting implications for the effects of agricultural prices on rural poverty. Interestingly, one historical legacy that the three East Asian countries where 'multifunctionality' argument has gained prominence (i.e., Taiwan, South Korea and Japan) have in common is the extensive and successful re-distributive land reform in the post-war period. Such land reform programs, made possible by the historically rare windows of opportunity to overcome or circumvent the typical resistance by the politically-powerful landed class (i.e., the occupation by the Allied forces in Japan, the absence of the landed elite in Taiwan and in South Korea), virtually eliminated tenant farmers and landless laborer households and established, instead, rural economies predominantly consisting of small-scale owner farms (e.g., see Hayami, et al. 1990). Similar conditions have never been replicated elsewhere in Asia (and, perhaps, anywhere else in the world). Today, in many of the rural areas of developing Asia, tenancy is still common and the class of the landless laborer households expanded rapidly in many countries after the 1970s.

One major policy implication arising from this contrast has to do with the role of agricultural price with regard to rural poverty. Since the average income tend to be lower in rural areas than in urban areas in both developed and developing countries, agricultural prices can have major implications for poverty in both rich and poor countries. In Japan, for example, where the problem of poverty is more of relative rather than absolute poverty, since the rural population (who is relatively poorer than the urban population) is predominantly owner-farmers (who tend to be net sellers of rice) higher agricultural prices tend to be 'pro-poor' (at least) in rural areas. In contrast, in many developing countries, where a large proportion of the rural population is composed of marginal farmers and of the landless who are net-buyers of staple food, lower (rather than higher) agricultural prices tend to be 'pro-poor.' One recent report based on household-level survey data, for example, finds that as much as 80% of the rural poor (which included small farmers as well as the landless) is net-buyers of rice in the rural Philippines (Fuwa 2006). As is well known, in post-war Japan, the government-supported price of rice was kept substantially above the market-clearing price level, which partially served as a re-distributive policy in the rapidly growing economy with increasing urban-rural disparities. In Japan (as well as in Taiwan and Korea), paying higher prices for rice is not only environmentally friendly according to the 'multifunctionality argument', but it was also pro-poor. In developing countries outside East Asia, however, paying higher prices for rice is likely to be anti-poor.

3. Biodiversity benefits of *in situ* conservation of traditional rice varieties

Any loss of biodiversity is irreversible. Despite the general emphasis on negative externalities in developing countries, as we discussed above, in recent years losses in biodiversity have been increasingly recognized as a major policy issue in developing, as well as in developed, countries. Genetic diversity is an important component for the continuous improvements of rice crops as cultivars need to be invigorated every 5 to 15 years to better protect them against diseases and pests (IRRI 2004). Furthermore, the recent advances in biotechnology have led to a renewed recognition of the importance of maintaining biodiversity as the basis for technological breakthroughs. Commercial rice production also relies heavily on the genetic diversity of rice as a source of material for plant breeding and improvement (IRRI 2004, 25). In addition to the potential roles of traditional rice varieties as raw materials for genetic improvements, the use of traditional varieties has been found to be potentially effective in controlling certain types of pests. For example, recent experiments conducted in the southwestern province of Yunnan, China, have found that intercropping rows of different rice varieties can control the rice blast disease 'that costs the rice industry millions of dollars annually.' The cropping practice allows blast-susceptible traditional varieties to be conserved *in situ* and also reduces the cost of pesticides (IRRI 2004, 27).

While there exist some estimated 140,000 rice varieties, it is widely recognized that the number of rice varieties has declined dramatically, especially since the introduction of the high-yielding rice varieties (HYVs) in the 1960s. In the Philippines alone, there were "more than a few thousand" rice varieties grown in the 1950s. Today, only two varieties cover 98% of the land planted with rice (IRRI 2004, 24-25).

In the following analysis, we focus on the practice of growing 'traditional' rice varieties, i.e., *in situ* on-farm conservation of traditional varieties, as an environmentally friendly agricultural technology that the government might consider encouraging farmers to 'adopt.' The potential advantages of on-farm (*in situ*) conservation of biodiversity, in contrast with *ex situ* conservation, such as a gene bank, include the following (Tuan et.al., 2003):

- on-farm conservation conserves the evolutionary processes of local adaptation of crops to their environments;
- it conserves diversity at all levels—the ecosystem, the species, and the genetic diversity within species;
- it conserves ecosystem services critical to the functioning of the Earth's life-support system, thus improving the livelihoods for resource-poor farmers through economic and social development;
- it maintains or increases farmers' control over and access to crop genetic resources;
- it ensures farmers' efforts are an integral part of national PGR systems and involves farmers directly in developing options for adding benefits of local crop diversity; and
- it links the farming community to gene banks for conservation and utilization (Jarvis *et al*. 2000a).

Due to the absence of sufficient information that would allow us to estimate potential values of biodiversity conservation from paddy rice cultivation in the Philippine context, however, our focus here is exclusively on the cost side (i.e., how much would it cost to induce farmers to adopt farming practices that would provide certain environmental services as externalities?) and not on the benefit side (e.g., valuation of environmental services). Needless to say, policy decisions would need to be based on both the cost (as pursued here) and the benefit (not pursued here) sides of alternative policy instruments.

4. The empirical model: treatment effects and the choice of cultivating traditional rice variety

Out empirical approach draws from the literature on microeconometric evaluation of programs and policies (see the work of Heckman, 1974; Heckman, 1976; Heckman and Robb, 1985). These studies have used alternative methods to estimate the value of green subsidies. For example, Kurkalova et. al., 2003 estimated the incentive payments in the form of an irreversibility and risk premium needed to induce the adoption of conservation tillage. They estimate this premium as one that is over and above the compensation for expected profit losses. Other studies have resorted to direct questioning or CVM type of techniques to estimate adoption subsidies (see Lohr and Park, 1995). Unlike the Antle and Stoorvogel (2006) study that used a simulation model to study carbon soil sequestration contracts, we use a revealed preference approach in the estimation of green subsidies for rice intra specific agrobiodiversity. We employ similar concepts as with Kurkalova et. al., 2003 but limited only to compensation for expected profit loss.

In light of the potential trade-offs between farm profit and conservation, we first estimate the likely losses in farm profits due to the adoption of traditional rice variety cultivation, and then discuss potential amount of subsidies needed to be provided to the farmers as an environmental service payment under alternative policy scenarios. The general model that we use in this case study is the following endogenous switching model:

$$\pi^{a}_{i} = X_i\beta^{a} + u^{a}_{i} \qquad \text{if TV cultivation adopted} \qquad (1a)$$

$$\pi^{na}_{i,} = X_i\beta^{na} + u^{na}_{i} \qquad \text{if TV cultivation not adopted} \qquad (1b)$$

$$I^{*}_{i} = Z_i\gamma + \varepsilon_i \qquad (1c)$$

$$I_i = 1 \text{ (TV cultivation adopted)} \quad \text{if } I^*_i > 0$$

$$0 \text{ (TV cultivation not adopted) if } I^*_i < 0$$

where π^a_i is the profit of parcel i adopting traditional varieties, while π^{na}_i is the profit of parcel i not adopting traditional varieties. X_i is the respective matrices of independent variables. I_i is the indicator variable representing the adoption decision of the farm household on parcel i. Households adopt traditional varieties (I=1) if and only if $I^* > 0$, otherwise the farmers plant modern varieties only (I=0). The endogenous switching regression model is appropriate if the participation or adoption decision is an endogenous choice. Simple OLS estimation is likely to yield inconsistent estimates.

The first step in calculating incentive payments for technology adoption is to identify factors that affect the level of rice farming profits, i.e. estimation of equation (1a)-(1c) through a two-stage estimation. Following Maddala (1983, 224-225), we initially estimate (1c) using the probit maximum likelihood method. We then use the estimated coefficient vector $\hat{\gamma}$ to calculate the inverse Mills ratios:

$$E(u^a_i \mid \varepsilon_i \le Z_i\gamma) = -\sigma^a_u \frac{\phi(Z_i\gamma)}{\Phi(Z_i\gamma)} \text{ and}$$

$$E(u^{na}_i \mid \varepsilon_i \ge Z_i\gamma) = \sigma^{na}_u \frac{\phi(Z_i\gamma)}{1-\Phi(Z_i\gamma)},$$

which are added to estimate equations (1a) and (1b), respectively, to estimate β^a and β^{na} by Ordinary Least Squares:

$$\pi^a_i = X_i\beta^a - \sigma^a_u \frac{\phi(Z_i\gamma)}{\Phi(Z_i\gamma)} + u^a_i \qquad \text{for } I_i=1 \qquad (1a')$$

$$\pi^{na}_{i,} = X_i\beta^{na} + \sigma^{na}_u \frac{\phi(Z_i\gamma)}{1-\Phi(Z_i\gamma)} + u^{na}_i \qquad \text{for } I_i=0 \qquad (1b')$$

The vector of the determinants of profit X_i include: the age of the household head, its square, years of schooling of the head, household size, demographic composition of the household members, the distance from the nearest market, the size of landholding, the share of hilly or rolling land areas, irrigation dummy, and province dummy variables. In addition to the variables included in the vector X_i, the determinants of technology adoption (Z_i) include, as identifying instruments, dummy variables for access to drying facilities, access to storage facilities and access to extension services. The underlying assumption is that access to those post-harvest facilities and access to extension services affect the decision to plant traditional varieties but do not directly affect farm profit once the adoption of modern rice varieties is controlled for.

The net benefits from planting traditional varieties then are obtained by calculating the counterfactual profit. The counterfactual profit is the expected income if, for instance, a non-adopting or pure modern variety farmer is forced to plant traditional varieties on their farm. In equation form the subsidy or the net benefit required to compensate a farmer for technology shifts can be obtained by:

$$\Delta = E[\pi_{na} \mid I^*_i < 0] - E[\pi_a \mid I^*_i < 0] \qquad (2)$$

Since there is the possibility of having negative profits, i.e. the actual profit being less than the counterfactual profit, then the required subsidy or conservation payments to promote agrobiodiversity in the farm is simply: $subsidy = \min(0, \Delta)$.

The next step in our analysis is to assess the likely impact of conservation payments on the levels of poverty. The headcount poverty ratio is used to assess the changes in the poverty levels with and without the conservation payment scheme. The official provincial poverty lines constructed by the National Statistical Coordination Board are used as the basis for computing the headcount poverty ratio.

5. The Data Set

The dataset for our analysis is taken from the Comprehensive Agrarian Reform Program Impact Assessment Project. This data set came from a nationwide survey of 1,855 farm households initially collected for the purpose of assessing the impact of the Comprehensive Agrarian Reform Program. It contains detailed demographic, socio-economic, and farm production data. A total subsample of 1,041 *rice* farming households was used.

Table 1 and 2 are cross tabulations that describe the data set in terms of the number of households and parcels under Traditional and Modern Variety cultivation. Around 42% of all households planted only modern varieties while 25% were pure traditional variety cultivators. The same percentages are observed for the parcels. This means that modern varieties are more widely cultivated by households and that more plots are planted solely for modern varieties. On the other hand, households who cultivate both traditional and modern varieties account for only 23% of the sample. In terms of parcels, only 20% of all parcels are planted with both modern and traditional varieties. This means that there is a relatively lower level of agrobiodiversity within parcels and geographically.

Table 1. Number of Households, by Type of Rice Variety Cultivation

	No. of HH Not Planting Modern Varieties	No. of HH Planting Modern Varieties	Total
No. of HH Not Planting Trad Varieties	108	436	544
No. of HH Planting Trad Varieties	262	235	497
Total	370	671	1,041

Table 2. Number of Parcels, by Type of Rice Variety Cultivation

	No. of Parcels Not Planted with Modern Varieties	No. of Parcels Planted with Modern Varieties	Total
No. of Parcels Not Planted withTrad Varieties	258	1,075	1,333
No. of Parcels Planted with Trad Varieties	569	485	1,054
Total	827	1,560	2,387

Table 3. Mean Values of Household Characteristics, by Type of Rice Variety Cultivation

Variable	Pure Trad Rice Farming HH (N=262)	Pure Modern Rice Farming HH (N=436)	Both Modern Variety and Trad Variety Farming HH (N=235)
Total Income (pesos)	77,182	131,632	101,970
Age of HH Head	55.6	55.9	56.7
Education Level of HH Head (years)	2.1	2.7	2.4
HH Size	5.3	5.4	5.2
Productive Assets (pesos)	15,245	23,047	26,640
Distance to market (km)	0.44	0.34	0.42
Access to Drying Facilities (dummy)	0.21	0.69	0.72
Access to Storage Facilities (dummy)	0.05	0.14	0.08
Extension Services (dummy)	0.67	0.82	0.75
Male HH Members (0 - 15 years old)	0.85	0.84	0.81
Female HH Members (0-15 years old)	0.79	0.70	0.66
Male HH Members (15 -60 years old)	1.46	1.57	1.50
Female HH Members (15 -60 years old)	1.39	1.53	1.43
Male HH Members above 60 years Old	0.35	0.32	0.34
Total Farm Area (hectare)	6.33	3.38	2.12

In terms of household characteristics, pure traditional variety cultivators tend to have lower incomes, lower level of education, fewer productive assets, less access to post harvest facilities, are farther away from markets, but have larger farms compared to both pure modern variety cultivator. In terms of these same characteristics, agrodiverse rice farming households fall in between pure modern variety and traditional cultivators. The overall trend is that for most of the mentioned variables, agrodiverse farming households are better than pure traditional cultivators but are relatively worst off compared to pure modern variety cultivators. These observations suggest that there would be potential opportunity costs in any scheme that attempts to induce pure modern variety users to adopt traditional varieties in their farms.

6. Factors Affecting Rice Variety Choice Among Farmers

The results of the probit estimation of adopting traditional rice variety cultivation are shown in Table 4. Households with better educated household heads tend to have lower probability of adopting traditional rice varieties in their parcels although the estimated coefficient is statistically significant only at 15%. Households with larger amount of productive assets are also more likely to adopt traditional rice variety, which is rather surprising. Demographic composition of the household also has some effects on the decision to adopt traditional rice varieties. In particular, households with more female members between the working ages of 15 to 60 are less likely to adopt traditional variety.

Exposure to extension services also reduces the probability of traditional variety adoption. This is not surprising since most extension agents have encouraged adoption of modern rice varieties. Furthermore, private seed suppliers and input dealers often provide extension services that also promote modern varieties through various contractual arrangements. Access to storage and drying facilities also reduces the probability of adoption of traditional varieties. This probably just captures the fact that post-harvest facilities in the Philippines are not very efficient. In addition, also important is land topography; having larger shares of rolling or hilly land areas is associated with a significantly (at 6% level of significance) lower probability of traditional rice variety cultivation, which is rather surprising.

Also shown in Table 4 are the computed marginal effects of each of the variables. Having an additional 100,000 peso worth of productive assets is associated with 5 percentage point increase in the probability of adopting traditional varieties, while additional year of schooling lowers the adoption probability by a 2 percentage point. Exposure to extension services appears to have quantitatively large effects, a 9 percentage point increase in the probability of adoption.

Table 4. Probit Estimation of the Choice of Planting Traditional Rice Varieties

Variable	Coefficient	P-value	Marginal Effects
Age of Household Head (year)	-0.008	0.698	0.003
Age of Household Head Squared (year)	0.000	0.808	0.000
Education of Household Head (year)	-0.025	0.154	-0.010
Household Size	0.024	0.564	0.010
Assets (pesos)	1.74e-06**	0.002	0.0691 (per 100,000)
Male HH Members (0 - 15 years old)	-0.046	0.360	-0.019
Female HH Members (0-15 years old)	0.021	0.672	0.009
Male HH Members (15 -60 years old)	-0.031	0.507	-0.013
Female HH Members (15 -60 years old)	-0.116**	0.011	-0.046
Male HH Members above 60 years Old	0.054	0.54	0.021
Distance to Market (km)	0.000	0.977	0.000
Access to Drying Facilities (dummy)	-0.164**	0.017	-0.065
Access to Storage Facilities (dummy)	-0.215**	0.040	-0.084
Extension Services (dummy)	-0.288**	0.000	-0.114
Land Allocation (hectare)	-0.072	0.007	-0.029
Share of hilly land	-0.157*	0.086	-0.063
Irrigated	-0.099	0.130	-0.039
Constant※	0.898	0.159	
Log likelihood	-1487.44		
Pseudo R2	0.1202		

** - significant at 5% level

* - significant at 10% level

※ provincial dummies are also included but not reported here.

7. Rice Farming Profits and Traditional Varieties

Table 5 and Table 6 show the estimation results of the determinants of farm profit per hectare using endogenous switching regression model (i.e., equations 1a' and 1b', respectively): table 5 corresponds to the parcels planted with traditional varieties (TV 'regime') and table 6 corresponds to the parcels *not* planted with traditional varieties. The signs of the coefficients are mostly the same between the two 'regimes.' One contrasting point estimates are, however, the education of household head; the estimated coefficient is negative for TV parcels while it is positive for non-TV parcels although the coefficient is only marginally statistically significant only for the latter.

Also the negative coefficient on the size of land, under the both 'regimes,' suggests diminishing returns to scale, in line with the often-found empirical regularity in developing agriculture of the "inverse relationship between land size and productivity." The point estimate of the magnitude of the inverse relations, however, is about twice as large on TV parcels as it is on non-TV parcels. Not surprisingly, the amount of productive assets (other than land), such as agricultural machinery, is positively and significantly associated with per hectare profit in both cases. As expected as well, access to irrigation has significantly positive effects on profit only for modern variety cultivation but not for TV cultivation.

Table 5. Determinants of Rice Farm Profit (per hectare): TV adopters

Variable	Coefficient	P-value
Age of Household Head	-168.759	0.56
Age of Household Head squared	3.077	0.22
Education of Household Head	-114.126	0.67
Household Size	-403.918	0.51
Productive Assets	0.0162**	0.03
Male HH Members (0 - 15 years old)	213.442	0.75
Female HH Members (0-15 years old)	1430.69*	0.05
Male HH Members (15 -60 years old)	463.094	0.53
Female HH Members (15 -60 years old)	895.381	0.25
Male HH Members above 60 years Old	-375.583	0.78
Distance to Market	-59.130	0.52
Land Allocation	-3360.665**	0.00
Share of hilly land	953.447	0.41
irrigated (dummy)	-361.505	0.73
Mills ratio	4915.722	0.24
Constant※	6812.96	0.44
R squared	0.2105	

** - significant at 5% level * - significant at 10% level

※ provincial dummies are also included but not reported here.

We find that coefficients on the Mill's ratio is not statistically significant in either 'regime,' implying that the correlation in the error terms between the profit determination functions (i. e., equations 1a' and 1b') the determinants of the traditional variety adoption (i.e., equation 1c) are not strong.[2]

[2] In our earlier estimation without including the provincial fixed-effects (but with regional dummies only) we found that the coefficients for the Mills ratios were statistically significant for both equations (as reported in Fuwa and Sajise, forthcoming). Thus, it appears that the main sources of endogeneity biases in this particular case arise mainly from the unobserved characteristics at the provincial level.

Table 6. Determinants of Rice Farm Profit (per hectare): TV non-adopters

Variable	Coefficient	P-value
Age of Household Head	507.293**	0.03
Age of Household Head	-3.755*	0.07
Education of Household Head	392.491	0.13
Household Size	-21.249	0.96
Productive Assets	0.0263**	0.04
Male HH Members (0 - 15 years old)	-48.583	0.92
Female HH Members (0-15 years old)	957.244	0.30
Male HH Members (15 -60 years old)	297.931	0.60
Female HH Members (15 -60 years old)	-227.145	0.69
Male HH Members above 60 years Old	-139.123	0.90
Distance to Market	-354.057**	0.01
Land Allocation	-1404.419**	0.00
Share of hilly land	1148.463	0.76
irrigated (dummy)	2166.642**	0.02
Mills ratio	-2767.464	0.55
Constant※	-4449.066	0.53
R squared	0.1486	

** - significant at 5% level * - significant at 10% level

※ provincial dummies are also included but not reported here.

8. Conservation Payments and Their Impacts on Poverty Levels

The counterfactual rice profit based on equation (1a') above can provide the necessary conservation payment that would compensate households for shifting to more agrodiverse rice farms. Under the hypothetical (first best) subsidy for the traditional variety introduction scheme, each household currently *not* planting traditional varieties is assumed to be paid a subsidy to compensate for the losses due to the adoption of traditional varieties. The estimated subsidy needed for each household is calculated based on the counterfactual profit obtained as the fitted value using the regression equation in table 5 applied to the plots currently not planted with traditional varieties (i.e., those observations with I=0, which are the observations used to estimate equation (1b') as reported in table 6). The mean subsidy payment based on the scheme is estimated to be Php 13,613 per parcel. This direct payment scheme would cost the total of around PhP 15,383,216 to implement in total.

Under the hypothetical policy scheme of providing subsidies to convert farms exclusively planted with modern rice varieties to plant (at least partially) traditional varieties, a total of 514 or 49% of the sample (of 1,041) households in our dataset would be eligible to receive such subsidies. Most of these households, on average, have significantly higher pre-subsidy incomes, and slightly larger farms than their non-eligible counterparts as shown in Table 7. Other household characteristics, such as schooling, age, the value of productive assets and household size, are roughly the same between the two groups.

Table 7. Mean Values of Characteristics of Eligible and Non-Eligible Farmers

Variable	Eligible HH (N=514)	Non Eligible HH (N=527)
Total Income (pesos)	125,113	89,134
Total rice profit (pesos)	30,567	22,461
Age of HH Head	55.9	56.4
Education Level of HH Head (years)	2.6	2.3
HH Size	5.3	5.3
Productive Assets (pesos)	21,970	20,115
Distance to market (km)	0.48	0.43
Access to Drying Facilities (dummy)	0.41	0.29
Access to Storage Facilities(dummy)	0.12	0.06
Extension Services(dummy)	0.79	0.72
Total Area (ha)	3.05	2.59

Under this subsidy scheme, the total of PhP 15,383,216 is distributed among 514 eligible households (1st column in Table 8). Since some of the beneficiary households live below the poverty line, this hypothetical subsidy scheme contributes to a modest decline in the headcount poverty ratio from 39.0% to 34.3%, a 12% decline in the headcount poverty ratio (the 2nd and 3rd column in Table 9). As we have seen, however, those households that are not currently planting traditional varieties tend to be slightly better educated and to have higher profit and income, thus those households who are likely to be the subsidy recipients tend to be relatively better-off households. This suggests a likely trade-off between the policy goals of pursuing biodiversity and that of poverty reduction, in this particular context. As a benchmark to see such a trade-off, we could consider an alternative hypothetical subsidy scheme where the same total amount of PhP 15,383,216 would be distributed equally among all households (PhP 14,777 each), a totally untargeted lump-sum subsidy scheme (2nd^{t} column in Table 8). Such a subsidy scheme would reduce the headcount poverty ratio to 26%, leading to a roughly 34% decline, compared to the 12% decline under the conservation subsidy scheme, in the headcount ratio (4^{nd} and 5^{rd} column in Table 9). Under this scheme, however, traditional varieties would be introduced only a fraction of the lands; there would be an estimated 'leakage' of 356 hectares or 23% of the land that would not be converted (at least partially) to traditional rice varieties, while 100% of the eligible parcels, by design, would be planted (at least partially) with traditional varieties under the 'first best' subsidy scheme. Thus, even the totally untargeted subsidy payment is much more 'pro-poor' than the hypothetical conservation payment scheme considered here.

In order to assess the potential opportunity costs of the conservation payment scheme in terms of poverty reduction, we can alternatively consider a poverty focused uniform payment scheme, holding the total subsidy budget constant at PhP 15,383,216, where all the households living below the poverty line would receive a uniform amount of PhP 37,890. This would obviously be much preferred from poverty reduction standpoint compared to the totally untargeted subsidy. Under this payment scheme, the headcount poverty ratio would decline to 12%, a 68% decline compared to the pre-subsidy poverty incidence (6th and 7th column in Table 9). Comparing the headcount poverty ratio under the '1^{st} best' subsidy scheme, 34% (found in the 2^{nd} column of Table 9), and the poverty ratio under the 'uniform poverty subsidy', 12% (found in the 6th column of Table 9), the difference between the two poverty ratios (i.e., 22 percentage points) can roughly be seen as the opportunity costs *in terms of poverty reduction (forgone)* for policy makers associated with the conservation subsidy payment (a PES) scheme under consideration.

At the same time, however, the likely 'leakage' in land conversion to traditional rice varieties would increase to 35% of the eligible parcels from 23% under the totally-untargeted subsidy scheme. Our example thus illustrates a case of direct trade-offs between the policy goals of biodiversity conservation and poverty reduction. This is essentially because (1) the kind of biodiversity we are considering here involves the adoption of a technology that would typically lead to loss in farm profit, (2) those households who are already practicing this 'environmentally friendly' technology tend to be less wealthy farmers while better-off farmers tend not be using the technology, and, therefore, (3) the environmental service payment would need to be targeted to those non-adopter farmers, who happen to be better-off farmers. As a result, given the same amount of budget, a subsidy scheme that is more efficient in inducing the adoption of traditional rice varieties is less pro-poor, while more pro-poor subsidy schemes tend to be less efficient as conservation payment schemes. In this particular application, therefore, policy makers would need to strike a balance between the two competing policy objectives.

Apart from the possible trade-offs between the environment and poverty reduction goals, another potential trade-off that policy makers are likely to face is the possible trade-off between the efficiency of payment scheme and the increase in the cost of information required for implementing subsidy schemes. The first best subsidy scheme we considered above (i.e., 1st column of Table 8) assumes that the government is able to elicit the information on both the current and the counterfactual profit (where currently non-adopters of traditional varieties adopt such a technology) from each household. Since this is rather unrealistic, we could consider some other subsidy schemes that are less stringent in information requirement. One alternative is to distribute a uniform amount among all the farmers who are currently not adopting traditional varieties. Such a subsidy, holding the total subsidy amount constant at PhP 15,383,216, would amount to distributing a subsidy of Php 29,928 (in lieu of parcel specific subsidy corresponding to prospective profit losses) to each eligible household (where the farmer are not currently planting traditional varieties). This subsidy scheme, not surprisingly, is less efficient than the first best conservation subsidy scheme (where the expected leakage is zero by design) leading to a leakage in land conversion of 11% (4th column of Table 8). The poverty reduction impact under this scheme, however, is larger than that of the 'first best' conservation scheme considered above; this scheme would lead to a 25% reduction in poverty incidence, compared to the 12% reduction under the 'first best' scenario (8th and 9th columns in table 9).

Table 8. Alterative policy scenarios for conservation/poverty subsidy payment

	(1) household specific payment	(2) untargeted lump-sum subsidy	(3) uniform poverty subsidy	(4) uniform conservation payment
total subsidy cost (pesos)	15,383,216			
eligibility criterion	non-TV cultivators expected to incur losses from TV adoption	none	below poverty line	currently not planting traditional varieties
number of beneficiaries	514	1,041	406	514
Subsidy amount	parcel specific	uniform among households	uniform among poor households	uniform among MV households
Amount per beneficiary	29,928 (average)	14,777	37,890	29,928
Leakage (land areas not planted TV) (hectares) (% of eligible land)	0 0	355.6 (22.7)	551.4 (35.2)	169.1 (10.8)

Table 9. Headcount Poverty Ratio under Alternative Policy Scenarios

Region	Status Quo	household specific payment	% change	untarget-ed lump-sum subsidy	% change	uniform poverty subsidy	% change	uniform conservation payment	% change
all regions	39.0	34.3	-12.1	25.9	-33.6	12.4	-68.2	29.3	-24.9

The leakage share of land conversion under this subsidy scheme (i.e., 11%), however, is still much lower compared to the 23% and 35% under the untargeted lump-sum subsidy and the poverty-targeted subsidy, respectively. At the same time, however, the poverty reduction impact under this subsidy scheme is smaller; the headcount poverty ratio after this subsidy scheme is implemented would be 29% compared to 12% under the poverty focused subsidy scheme. This last scheme, therefore, might be seen as a middle ground option among the alternative payment schemes we have considered here, with a moderate leakage in terms of biodiversity conservation, a relatively modest information requirement and a better poverty reduction performance (compared to the first-best conservation payment scheme).[4]

9. Concluding remarks

This case study has shown the poverty implications and the cost of promoting agrobiodiversity in rice farming. Poverty effects of a direct conservation scheme appear to be quite sensitive to how the specific subsidy scheme is designed. Under this particular application of preserving traditional rice varieties in the Philippines, there is a clear trade-off between the two policy goals of enhancing biodiversity and poverty reduction. Even the totally untargeted lump-sum subsidy would have a larger poverty reduction impact than would the first-best conservation subsidy payment scheme. There is also a clear trade-off between the efficiency of targeted conservation payment and the information requirement for implementing subsidy schemes. While compensating the exact amount of profit losses due to technology adoption is obviously more efficient in terms of eliminating possible 'leakages,' the information requirement for such scheme is perhaps unrealistically high. One interesting result of our analysis is that a less informationally stringent, thus less efficient from conservation point of view, subsidy scheme is more pro-poor than the efficient subsidy scheme. Under this particular policy example, therefore, policy makers are likely to be required to strike a delicate balance between the two competing policy objectives.

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[4] In fact, there would be another issue of potentially perverse incentive effects. That is, the farmers currently planting traditional varieties may shift to modern varieties in order to (appear to) be 'eligible' for the subsidy scheme, which would lead to even larger leakages. While this is a real possibility this issue is not pursued further here.

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