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Is native timber tree intercropping an economically feasible alternative for smallholder farmers in the Philippines?

Fernando Santos Martin and Meine van Noordwijk†

Integration of trees on upland farms in the Philippines has been slower than expected and desirable from an environmental perspective. Our economic and risk analysis points to current policies as part of the problem. The study compares three domesticated indigenous timber trees (*Shorea contorta* V., *Pterocarpus indicus* J., and *Vitex parviflora* W.) intercropped with maize against a benchmark of the widely used exotic mahogany (*Swietenia macrophylla* K.). We used a biophysical simulation model (WaNuLCAS 3.1) to represent interaction between trees and crops for a fundamental level of water, nutrient and light capture as the basis for production functions. External conditions affecting systems profitability were accounted for in the Policy Analysis Matrix (PAM). Elements of risk were introduced through Monte Carlo simulation. Study results revealed that from a farmer's perspective intercropping systems provide similar (within an uncertainty range of + or − 10%) returns to monocropping scenarios. When net subsidies and taxes are accounted for, social profitability evaluations favour tree intercropping at high tree densities. The net effect of the current bias in price policies towards food production therefore refrains farmers from making decisions to integrate trees on farms; a decision that is actually in the national interest on economic grounds, even without consideration of positive environmental effects.

Key words: agricultural policy, agricultural systems, development economics, economic and risk analysis, productivity analysis.

1. Introduction

The Philippines is one of the most deforested countries of the tropical world (Kummer 1992; Schute 2002), and as such one might expect conditions to be right for the onset of an upward trend in tree cover in a 'Forest Transition' trajectory (Mather 1992). However, such transition is only expected if trees have an economic value relative to food crops that exceeds their ratio of resource use (Cannell *et al*. 1996; Van Noordwijk 1996), and/or if specific incentives exist for tree planting that can be socially justified by the provision of environmental services, such as terrestrial carbon storage. Widespread spontaneous on-farm tree planting may require not only a shift in forestry paradigm (Roshetko *et al*. 2008), but also a level playing field for the net effect of taxes and subsidies on the production of staple food crops versus tree

† Fernando Santos Martin (email: santosmartinfer@gmail.com) is at Forestry of Cordoba, University of Cordoba, Cordoba, Spain. Meine van Noordwijk, World Agroforestry Centre, Bogor, Indonesia.

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products. Such net effects can be quantified in a policy analysis matrix (PAM) format (Monke and Pearson 1989), which evaluates profitability at farmgate level, as experienced by farmers making daily decisions on resource use and impacts that apply at the national border by society at large.

Internationally, the competitiveness of the Philippines for commercial tree planting appears to be inferior to neighbouring countries such as Malaysia and Indonesia (Shimamoto *et al*. 2004). Results from the Global Forest Resources Assessment (FAO, 2006) indicate that the net loss of forests in Asia that persisted for many decades has now been halted. From 2000 to 2005, there was an annual net gain averaging just over 1 M ha, to which China, India and Vietnam were major contributors (Rudel *et al*. 2005). While most countries in the region are still losing forest area, Asia is the first continent to display a transition from net deforestation to net reforestation because systematic data collection of global forest resources began in the 20th century (Mather 2006). However, if international timber markets are further liberalised, market-driven reforestation will not occur in areas where market competitiveness is relatively low even though reforestation is badly needed in remote mountainous areas with steep slopes and/or poor soil conditions (Shimamoto *et al*. 2004).

The first wave of farmer tree planting in the Philippines focussed on fast-growing tree species, such as *Gmelina arborea* Roxb., *Paraserianthes falcataria* (L.) I. Nielsen and *Acacia mangium* Willd. as cash crops (Garrity and Mercado 1994). However, rapid adoption created an oversupply and subsequently a sharp decline in the price of farm-grown timber (Bertomeu 2004). At current prices, which include a net subsidy in maize production, the inclusion of low-quality timber in small-farm production systems is not profitable, and attention should focus on species with higher value per unit resource use. The benchmark for the latter is mahogany (*Swietenia macrophylla* K.). The current analysis compares a number of locally domesticated indigenous timber trees against this benchmark, by acknowledging the resource competition with food crops at the fundamental level of water, nutrient and light capture, the use of labour, external inputs and the combination of taxes and subsidies affecting profitability and elements of risk.

Many national policies that are intended to conserve and protect natural resources discourage the cultivation, and thus conservation, of native species by restricting their utilisation or trade (Tomich and Lewis 2001; Bertomeu 2004; Fay and Michon 2005). Moreover, taxation schemes that classify cultivated native tree products in the same way as those from natural forests significantly reduce the profitability of native-tree farming systems. Inappropriate interpretation and enforcement of national policies by local officials leads to further confusion. In response to these policies, or their perceptions of these policies, many smallholders choose not to cultivate native trees on a large scale and in many cases even actively remove the natural regeneration because the resultant trees cannot be ‘utilised’ (ITTO, 2001).

Alternative systems, as native tree intercropping, must be profitable and socially acceptable for smallholders; otherwise, they have little prospect for adoption and, hence, impact (Vosti *et al.* 2000; Tomich and Lewis 2001). A minimum set of three quantifiable socioeconomic objectives are judged necessary for the assessment of land use alternatives from smallholders' perspectives. Does it pay smallholders to invest in a particular production alternative compared with other options? Is it feasible for these households to supply the necessary labour themselves or to hire workers? Even if the alternative is profitable and feasible, given household labour constraints and labour-market conditions, is it too risky (either in terms of variance in food yields or as a source of income) as adoption might jeopardise the livelihood strategy?

The current economic analysis is part of a broader assessment of the technical aspects and opportunities for use of native trees in upland farming in the Philippines, analysing current farmer practice, aspects of tree-site matching and agronomy of agroforestry systems (Santos 2007). The objective of the study reported here was to assess whether intercropping systems with native species are an economically feasible alternative to maize monocropping or to intercropping with exotic species for smallholder upland farmers in terms of: (i) profitability, (ii) labour requirements, (iii) economic risk and (iv) current and potential future policy regimes on prices, taxes, market access and input subsidies.

Previous studies were based on empirical data and used econometric models, without a biophysical basis. As the experience with on-farm management of high-quality native timbers is limited as yet, we used a bio-economic modelling approach that integrates biological, agronomic, economic and policy aspects.

Current global debate on the environmental benefits of enhanced tree cover and terrestrial carbon storage on agricultural lands still starts from the assumption that positive incentives and project incentives are needed for meeting a targeted increase of adoption of trees on farm. Our study explored whether removing existing disincentives that derive from subsidies for food crops might be a sufficient trigger to achieve such a goal and can become part of national policy reform.

2. Methods

2.1. Choice of biophysical model to derive local production functions

For this study, we used the WaNuLCAS 3.01 model of Water, Nutrient and Light Capture in Agroforestry Systems (Van Noordwijk *et al.* 2004) to explore a broad range of options and zoom in on the tree-crop combinations that are most likely to meet farmers' expectations. WaNuLCAS 3.1 was selected because it has sufficient flexibility to handle the range of production systems and can be used when basic tree and crop parameters are adjusted to local settings.

Aboveground biomass allometric equations for three native trees found under local conditions were derived from the WanFBA module (Van Noordwijk 1999). In a separate paper, we analysed the validity of use of the model for local circumstances and the four tree species (Santos and van Noordwijk 2009). For each tree species, simulations for an initial 10-year period were compared with empirical field measurements with satisfactory results. Tree functional parameters for *Swietenia macrophylla* K. as a comparator were taken from WaNuLCAS 3.1 tree library.

The starting point of the study was the identification of existing tree growing practice in the study area (Tabango, Leyte, Central Philippines). Three native timber tree species were commonly found on farmers' fields as part of different types of agroforestry systems: *Shorea contorta* V., *Pterocarpus indicus* J. and *Vitex parviflora*. One widely spread exotic species (*Swietenia macrophylla* K.) was also found and was included in the study as comparator. We picked this species based on the recommendation from IUCN (1987) that exotic tree introductions should only be contemplated if no native species are suitable for the purpose for which the introduction is being made. The Municipality of Tabango was selected as the study site because it is representative of upland environments that are intensively cultivated, vastly degraded and where farmers have started to plant native timber trees as a strategy for livelihoods as well as recovering degraded uplands (Santos *et al*. 2010).

2.2. Land use systems analysed

Farmers make decisions at the field scale on a multiyear basis through strategic choices of tree species and spacing, which set the context for annual decisions at field scale through tactical decisions on cropping pattern and fertilisation. This determines the scope of daily crop and tree management (Van Noordwijk *et al*. 2004). Most, if not all, of these decisions are beyond the reach of a purely empirical approach, as the number of options is too vast.

WaNuLCAS 3.1 was used to provide simulation scenarios of a wide array of realistic management options that make a transition from crop monoculture towards tree-dominated systems. Thus, three possible land uses scenarios were characterised and simulated into the model for comparison purposes: (i) maize monocropping, (ii) hedgerow tree intercropping and (iii) tree monoculture.

All three scenarios were run with WaNuLCAS 3.1 for a period of 15 years (30 maize cropping seasons) which was considered a reasonable rotation period for selected tree species (Valdez 1991; Schute 2002). If applied to a hedgerow intercropping system, WaNuLCAS 3.1 allows for the evaluation of crop growth at different distances from tree hedgerows. With the objective to evaluate how tree planting pattern affects crop performance, the model was run at different tree densities (100, 200, 400, 800 trees/ha) and various combinations of alley width and intra-row spacing (Table 1).

Table 1 Intercropping systems simulated with WaNuLCAS 3.1 as a combination of three different levels of alley and intrarow spacing

Alley spacing (m)	Intrarow spacing (m)	Planting pattern (m)	Tree density (trees/ha)
20 (wide alley)	2.5	20*2.5	200
	5	20*5	100
	10	20*10	50
10 (middle alley)	2.5	10*2.5	400
	5	10*5	200
	10	10*10	100
5 (narrow alley)	2.5	5*2.5	800
	5	5*5	400
	10	5*10	200

Maize (*Zea mays* L.) was selected for simulation scenarios because it is the most preferred food crop among upland farmers in the Philippines (Groestschel *et al*. 2001). Utilisation of fertiliser (N and P) was assumed to be applied only to the crop during planting time for every cropping season. According to the model trees, benefits from these nutrient inputs as well and tree growth in agroforestry can exceed that in unfertilised tree monoculture (Santos and van Noordwijk 2009). For intercropping systems, N and P were applied in the simulation only to maize at an amount of 45 kg N/ha and 30 kg P_2O_5/ha as described by Stark (2003) who documented common upland farmers' practices for the Visayas Region, Central Philippines.

2.3. Socioeconomic analysis, taxes and subsidies

The use of labour, external inputs and the combination of taxes and subsidies affecting profitability were accounted for in this study using the PAM approach (Monke and Pearson 1989). The PAM approach was used because its associated output results differentiate between farmgate (private) prices and price conditions that reflect the national economy of the Philippines ('social prices'). PAM analysis requires a set of essential data on agricultural activities, market prices of each agricultural input and its associated output results to be included in the analysis. Tree and crop growth results from WaNulCAS 3.1 simulations were used as the output data to prepare detailed farm budgets (Table 2).

A farm level budget was constructed for each activity of the system. Input data collection began with a compilation of an inventory of tradable inputs required for each system (Appendix I). These items are categorised, quantified and priced, first in private and then in social terms. The cost and returns of each activity are added together to generate the total cost and returns for the commodity system. Labour accounting is carried out at farmgate level and excludes the labour involved in input production, processing and further activities in the value chain of farm products. Keeping track of direct labour

Table 2 WaNULCAS 3.1 output results (cumulative over 15 years) for maize monocropping and selected intercrop systems

Agricultural system			Output	
Name	Tree density (trees/ha)	Tree species	Maize yield (Mg/ha)	Timber (m^3/ha)
Maize monoculture	0	—	61.0	0
Native intercrop	100	*Shorea contorta*	49.7	18
Native intercrop	100	*Vitex parviflora*	44.2	47
Native intercrop	100	*Pterocarpus indicus*	51.9	30
Exotic intercrop	100	*Swietenia macrophylla*	47.5	112
Native intercrop	200	*S. contorta*	42.7	38
Native intercrop	200	*V. parviflora*	32.7	97
Native intercrop	200	*P. indicus*	47.5	78
Exotic intercrop	200	*S. macrophylla*	40.9	115
Native intercrop	400	*S. contorta*	42.6	44
Native intercrop	400	*V. parviflora*	29.1	126
Native intercrop	400	*P. indicus*	46.8	125
Exotic intercrop	400	*S. macrophylla*	41.6	166
Native intercrop	800	*S. contorta*	15.1	93
Native intercrop	800	*V. parviflora*	19.3	164
Native intercrop	800	*P. indicus*	26.2	196
Exotic intercrop	800	*S. macrophylla*	19.5	255

inputs separate from external inputs in the cost-benefit analysis facilitates the analysis of the system's employment effects.

Farm level budgets require estimation of prices for all inputs and outputs. The study used local market prices as the basis of calculation of farm budget valued at private prices. For the comparable farm budget at social prices, the study applied export or import parity prices at the farmgate as the basis of calculation. For example, to calculate timber price for native tree species (where wood products have not been traded on the markets for decades), market-equivalent values of native timber were based on market prices of forest products determined by the Department of Natural Resources (DENR, 1991). From this estimated market price (social price), the farmgate (private) price was derived by deducting 25 per cent for government taxes, with a second 25 per cent deduction for the product margin share as transportation and other transaction costs (formal and informal costs of the required permits, based on current practice).

Final farm level budget calculations were based on different macroeconomic assumptions prevailing in the Philippines (Appendix II). For example, a discount rate of 5.7 per cent equal to the inflation rate during data collection (September 2007) was chosen as the initial value for calculation to buffer profits from this condition. However, real private interest rates (at least for smallholders, if not for large corporations, which could secure subsidised credits) have been considerably higher. It is argued that a private discount rate equal to inflation is a very low limit for the real cost of capital for smallholders. Thus, discount rates of two and three times the initial inflation rate (11.4 and 17.1 per cent) were used for calculating net returns at social prices.

2.4. System response to external variability

Sensitivity analysis provides a way of assessing the impact of changed assumptions in estimating profitability. It can be applied to both private and social estimations. However, the social estimates of long run prices for output and the cost of capital are usually the most uncertain and hence receive the most attention in the sensitivity analysis (Monke and Pearson 1989). An elasticity parameter measured the responsiveness of each land use system to hypothetical changes to key parameters, ie, discount rate and output prices (timber and maize). Thus, elasticity is the proportional change in one variable relative to the proportional change in another variable ($E =$ per cent change in x/per cent change in y). Lower proportional values on elasticity were interpreted as the system being more robust to potential changes of key variables.

Elements of economic risk were introduced by Monte Carlo simulation. This method is based on the use of random numbers and statistical distributions of the various input parameters, with specified covariance structure or assumed independence. Economic risk analyses quantify the variability of benefits across agricultural systems in response to changes in macroeconomic conditions. Long-term records of price fluctuations and inflation rates were used to estimate the range of variability in uncertainty. For the discount rate, a hypothetical range of variability was set from its present value up to three times that value (5.7–17.1 per cent). For commodity prices, a range of variability from half to two times the present value was assumed. For maize, it was hypothesised that prices will fluctuate from \$65.5 to \$263.9 (US) per ton; while timber price would be varied between \$28.0 and \$111.9 (US) per m^3. As a result, a randomised combination of each parameter within its range of variability created a total number of 1210 observations. Each system was plotted and fitted under a normal distribution function to obtain a comparable profile of agricultural systems.

3. Results

3.1. Private and social profitability

Calculated profitability results for existing policies and macroeconomic conditions in the Philippines showed that tree intercropping provides very similar returns to maize monocropping scenarios from a farmer's perspective (private conditions), for the range of tree species and densities tested (approximate horizontal lines in Figure 1). However, when profitability calculations include associate social prices tree, intercrop systems yield considerable benefits with clear advantages at higher tree densities. Social benefits associated with tree

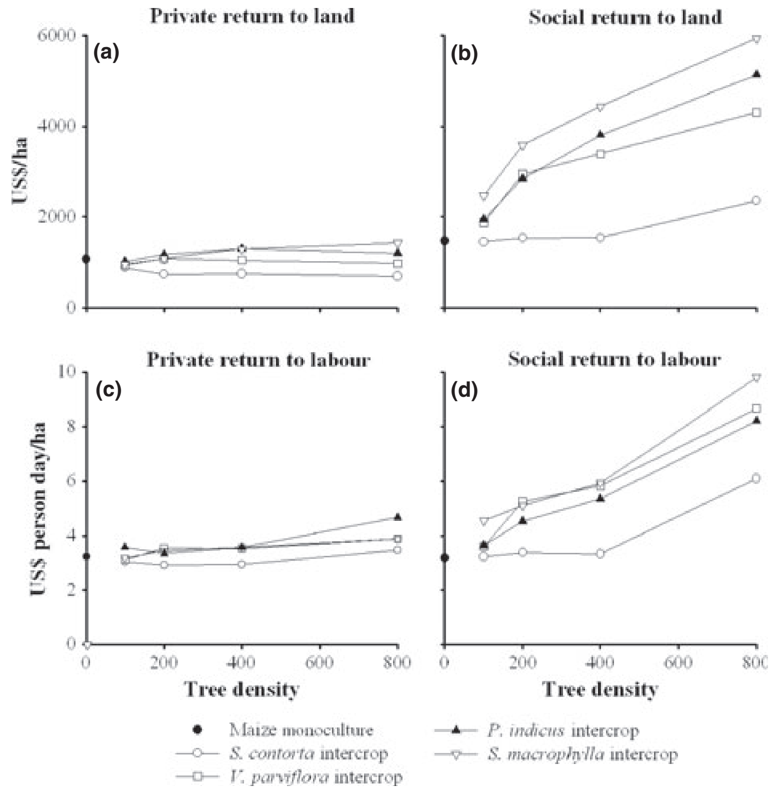

Figure 1 Policy analysis matrix (PAM) results for social and private profitability comparing maize monocropping and four intercrop systems at different tree densities: (a) private return to land; (b) social return to land; (c) private return to labour; (d) social return to labour.

intercrop systems in the calculations can be primarily attributed to the 50 per cent price differential on timber products, accounting for tax, transaction costs and informal charges. The assumed factor 2 difference in discount rate and cost of loans between smallholders and societies also contributes to the increasing difference between private and social profitability at increasing use of trees.

3.2. Labour requirements

With current parameters, tree intercropping systems reduced labour requirements only at higher tree densities (800 trees/ha) (Figure 2). Differences in labour requirement for each land use system are associated with tree-crop interactions because the model includes a rule that cropping will be automatically stopped after the first crop that reached a zero. Major differences in maize yield were found because of the widening effect of the alleys rather than the intra-row distance between trees. For instance, in planting patterns with narrow alleys (5 m), maize could be grown only in the early phase of the simulation, while for intermediate and wider crop alleys (10 and 20 m),

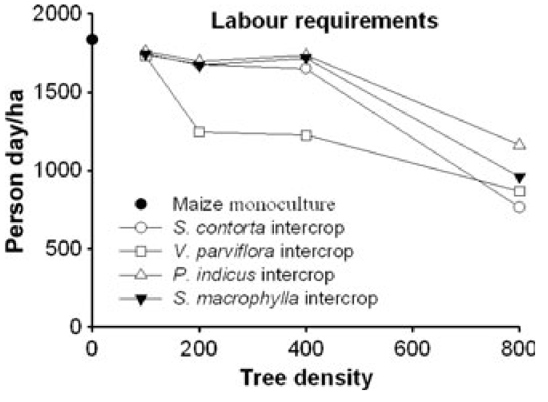

Figure 2 Labour requirements comparing maize monocropping and four intercrop systems at different tree densities.

continuous maize intercropping was feasible for all tree species. With planting patterns of 10 × 2.5 m (for 400 trees per ha) and 10 × 5 m (for 200 trees per ha), labour requirements to plant and maintain intercropped trees are very similar.

Based on those results, if farmers are constrained in household's labour, and they can assume the associated loss on crop productivity, targeting higher tree density will be an efficient management option. The different effects among tree species were also captured by the results. Major differences in maize yield were found for intercrop systems with *Vitex parviflora* where yield will start to drop at low and intermediate tree densities. *Vitex parviflora* was more competitive than other trees at intermediate densities with maize. Thus, model results suggest that intercropping systems with *Vitex parviflora* are only attractive at low tree densities.

3.3. Impact of external variability

Sensitivity analysis results showed that, as expected, the *discount rate* has a smaller effect on the crop component of the intercropping system than on the tree (Figure 3d). Rotation periods associated with trees (ie 15 years) involve a considerable uncertainty on the profits from the timber. As a result, maize monocropping scenarios can be considered more robust to the effect of discount rate (elasticity = 13 per cent) than intercrop systems (elasticity between 20 and 30 per cent). Another way to read these results is that with a discount rate equal to the inflation rate (5.7 per cent), all intercrop systems are just above the threshold of profitability set by the maize monocropping system. However, if inflation rates increase two or three times (11.4 or 17.1 per cent), some intercrop systems would fall below the threshold level (Figure 3a–c).

In relation to changes in commodity prices, sensitivity analysis results showed that maize monocropping systems are very sensitive to changes in

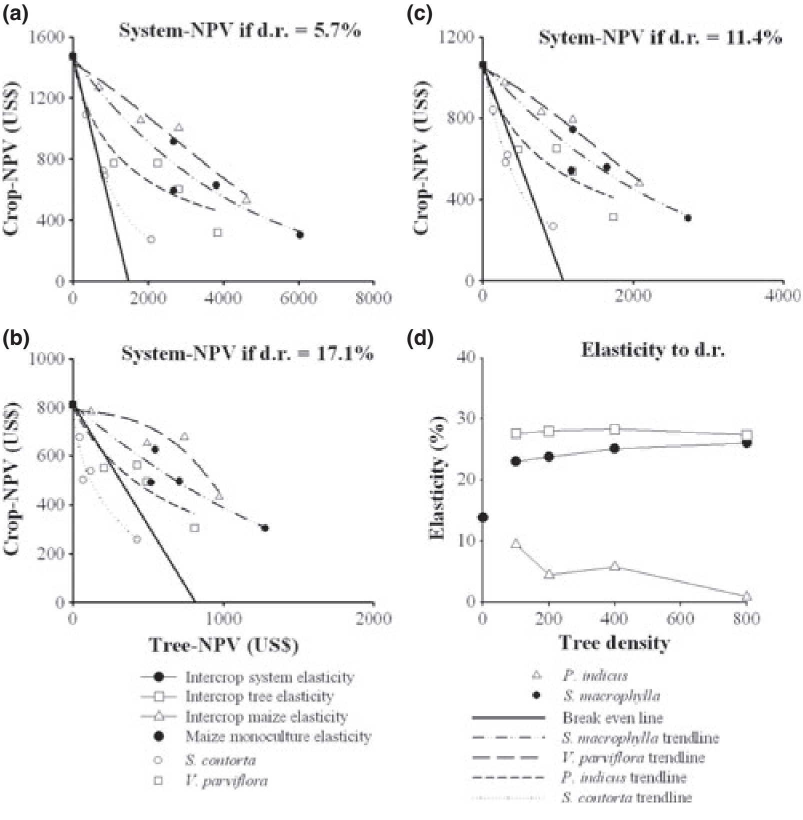

Figure 3 Sensitivity analyses results of intercrop systems to potential changes of discount rate (d.r.): (a) NPV if d.r. = 5.7; (b) NPV if d.r. = 11.4; (c) NPV if d.r. = 17.1 and (d) system elasticity comparing robustness of each agricultural systems to d.r. Systems above breakeven line (corresponding to maize monocropping threshold) are considered to be profitable.

output prices, and thus, farmers are assuming an important potential risk from this decision (Figure 4d). Instead, intercrop systems are more robust to output prices with a clear advantage if the priority is given to the tree. For example, if the price of maize increases by two (assuming that timber prices remain constant), all intercrop systems that were above the breakeven line fall below the threshold of profitability compared to maize monocropping (Figure 4b). However, if timber prices increase by a factor of two, with maize prices constant, all intercrop systems would be much more profitable than maize monocropping systems (Figure 4c).

3.4. Economic risk

Economic risk analysis in the face of uncertainty of all prices suggests that maize monocropping systems are exposed to real economic risks while all tree intercrop systems are partially buffered from this situation (Figure 5). Results show that timber is a key factor in increasing robustness against external vari-

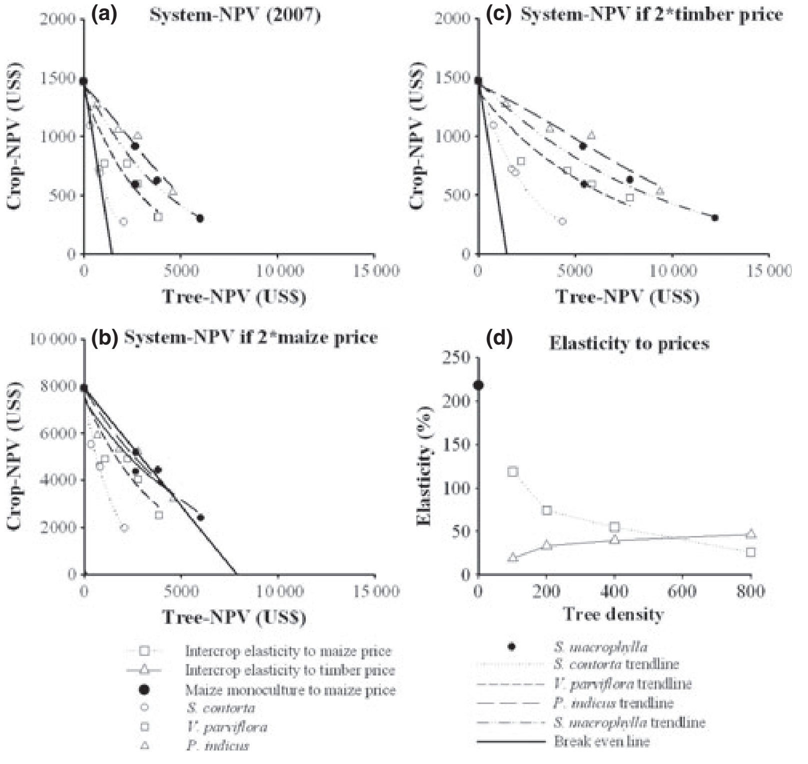

Figure 4 Sensitivity analyses results of intercrop systems to potential changes on commodity prices: (a) 2007 commodity prices; (b) if maize price doubles (assuming timber price remains constant); (c) if timber price doubles (assuming maize price remains constant) and (d) System elasticity comparing robustness of each agricultural systems to commodity prices. Systems above breakeven line (maize monocropping threshold) should be considered profitable.

ability and thus reducing economic risk. In 27 per cent of cases simulated, negative profitability values were found for maize monocropping. These results show that farmers are assuming an important potential economic risk when maintaining these systems (Figure 5b). Instead, intercropping systems always maintained positive values and were considerably higher than monocultures (Figure 5a). It is important to remember that this analysis was based on social price estimations suggesting that these results do not necessarily reflect farmers' perception of economic risks or short-term responses to differences price levels.

4. Discussion

With existing farmgate prices for medium- to high-quality timber, maize monocropping scenarios are as profitable as tree intercropping for all tree densities and species tested, within a ±10 per cent of uncertainty range. These results might explain why the majority of farmers remain hesitant in innovating with new intercropping systems and prefer monocultures of food

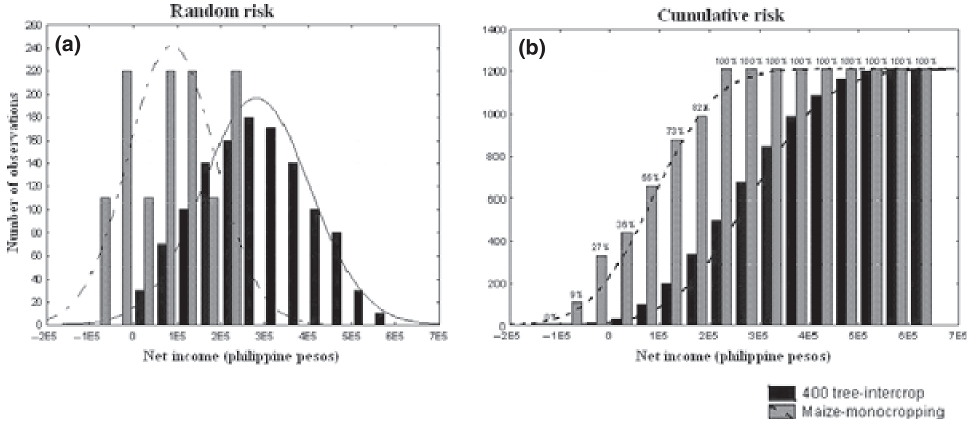

Figure 5 Monte Carlo simulation results showing economic risk distribution for maize monocropping and intercrop systems: (a) random risk; (b) cumulative risk. Negative profitability values show cases exposed to economic risk.

crops. The low economic incentives that farmers expect to receive from timber with existing policy and macroeconomic conditions in the Philippines make it less attractive to plant trees. However, low levels of tree adoption by farmers lead to considerable benefits foregone at social level. The study results indicated a significant social profit margin for tree intercropping scenarios even without accounting for environmental services the trees might provide. The divergence between private and social prices indicates 'policy failure' and perverse incentives where private decisions go against the greater good. Social benefits associated with tree intercropping should be attributed to the added value that timber produces in terms of legal and illegal rents and transaction costs. Thus, stimulating tree planting activities among smallholders and reducing divergences between social and private timber prices could ultimately reactivate forestry sector contributions to the overall national economy. For example, in Indonesia, it was found that reducing import tariffs and export taxes may also reduce the rate of upland degradation (Pearce *et al*. 1990; Coxhead 1997).

Because price risk appears to be the major deterrent to expansion of tree farming, measures to reduce risk or improve risk-coping mechanisms of farmers should be given the utmost importance in any upland development programme (Predo 2002). Provision of relevant and timely price information and subsidised crop insurance for both annual and tree crops are possibilities. Tree farming produces net benefits to farmers and society in terms of carbon sequestration services. Payments for environmental services (PES) to farmers may be needed to encourage expansion of tree-based land use systems in the absence of policy reform.

Currently discussed implementation modes for A/R-CDM and REDD+ (Van Noordwijk *et al*. 2008b) accounting in developing countries are trying to translate global interest in increased carbon storage into incentives on the ground. For the systems studied here, it appears that there is an 'institutional barrier' to be overcome to stimulate spontaneous adoption of tree-based land use systems, not a true economic one. With a levelling of the playing field between on-farm food and timber production, PES schemes may not be needed to achieve higher terrestrial carbon stocks in the Philippines, as well as higher rural income.

Moreover, stimulating the wood industry in rural-based communities could have a double purpose of bringing job opportunities and promoting tree farming systems with market linkages. When family labour is engaged in off-farm employment, farmers are more likely to invest in tree planting as a low-labour land use strategy (Dewees 1992; Tacher *et al*. 1996). Study results show that tree intercropping may be an effective household strategy to reduce labour requirements only if primary attention is given to the tree (higher tree density) instead to the food crop. At the local level, creation of off-farm job opportunities for younger generations might be a major concern for rural communities, and the forestry sector could help in achieving this goal (Fay and Michon 2005).

For nonindustrial tree planting, the arguments in favour of choosing from only a handful of globally promoted exotic species appear to be less convincing (Huges 1994). Study results revealed that native intercrop systems with three native species were as profitable as exotic systems under a wide range of management options. In addition to simple evaluation of species in terms of yield (the main criterion usually employed in species elimination trials), local species have the advantage of being noninvasive, well adapted to the environment, accepted by local people in most cases, useable in a wide range of existing applications supported by existing local knowledge, and may be important in the local culture. Thus, any government or nongovernment institution involved in promoting tree planting activities in the Philippines should first consider native over exotic species.

Three possibilities are open to the Philippine government to deal with these issues: (i) allocating substantial areas of state-controlled land to 'concessionaries' for development of a tree plantation industry, with a benefit sharing between the concessionaire and the state, (ii) stimulating target tree planting activities in the context of a 'national reforestation' programme and (iii) removal of constraints to spontaneous smallholder adoption of tree-based farming systems as part of their multifunctional landscapes. The first two options have been tried with limited success (Van Noordwijk *et al*. 2008a). There is considerable, untested, scope for this third option, as alternative to specific 'agroforestry policies' or public incentive schemes created to increase the use of trees in the landscape and obtain higher terrestrial carbon stocks.

In summary, this study suggests that (i) incorporating high-value trees in upland farming systems in the Philippines is economically feasible while reducing economic risk at the farm level, (ii) distortions that favour maize (food) over wood production on farms reduce the financial attractiveness of tree production for farmers to a neutral level and (iii) some native trees are at par or better than commonly used exotic trees. Policies aimed at the wider use of trees and specifically native trees in the landscape need to focus on levelling the playing field between food crops and wood, before designing any specific incentives.

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References

Bertomeu, M. (2004). *Smallholder Timber Production on Sloping Lands in the Philippines: A System Approach*. World Agroforestry Centre, Los Baños, Philippines.

Cannell, M.G.R., van Noordwijk, M. and Ong, C.K. (1996). The central agroforestry hypothesis: the trees must acquire resources that the crop would not otherwise acquire, *Agroforestry Systems* 33, 1–5.

Coxhead, I. (1997). Induced innovation and land degradation in developing country agriculture, *Australian Journal and Resource Economic* 41, 305–332.

Department of Natural Resources (1991). *Revised Forestry Code*. Department of Natural Resources, Manila, Philippines.

Dewees, P.A. (1992). *Social and Economic Incentives for Smallholder Tree Growing: A case study from Murang'a Distric, Kenya*. Food and Agricultural Organization, Rome.

FAO (2006). Global Forest Resources Assessment 2005, *Forestry Paper 147*, Rome.

Fay, C. and Michon, G. (2005). Redressing forestry hegemony: when a forestry regulatory framework is best replaced by an agrarian one, *Forest, Trees and Livelihoods* 15(2), 193–204.

Garrity, D.P. and Mercado, A. (1994). Reforestation through agroforestry: market driven small-holder timber production on the frontier, in Raintree, J.B. and Francisco, H.A. (eds), *Marketing of Multipurpose Tree Products in Asia*. Winrock International, Baguio City, Philippines, pp. 265–268.

Groestschel, A., Aquino, R., Buchholz, I., Eufracio-Mazo, T., Ibkendaz, A., Sales, N., Seven, J. and Vicentuan, K. (2001). *Natural Resource Management Strategies on Leyte Island, Philippines*. SLE, Berlin.

Huges, C.E. (1994). Risk of species introductions in tropical forestry, *Commonwealth Forestry Review* 73(4), 243–252.

ITTO (2001). *Annual Review and Assessment of the World Tropical Timber Situation 2001*. International Timber Trade Organization, Yokohama.

IUCN (1987). *The IUCN Position Statement on Translocation of Living Organisms*. World Conservation Union, Gland, Switzerland.

Kummer, D. (1992). Deforestation in the post-war Philippines, in Brown, K. and Pearce, D.W. (eds), *The Causes of Tropical Deforestation*. UCL Press, London, p. 177.

Mather, A.S. (1992). The Forest transition, *Area* 24, 367–379.

Mather, A.S. (2006). Recent Asian forest transitions in relation to forest transition theory, *International Forestry* 9(1), 491–502.

Monke, E.A. and Pearson, S.R. (1989). *The Policy Analysis Matrix for Agricultural Development*. Cornell University, Ithaca, New York.

Pearce, D.W., Barbier, E.B. and Markandya, A. (1990). *Sustainable Development: Economics and Environment in the Third World*. Earthscan Publications, London.
Predo, C.D. (2002). Bioeconomic Modeling of Alternative Land Uses for Grassland Areas and Farmers' Tree Growing Decisions in Misamis Oriental, *Philippines*. University of the Philippines, Los Baños.
Roshetko, J.M., Snelder, D.J., Lasco, R.D. and Van Noordwijk, M. (2008). Future challenge: a paradigm shift in the forestry sector, in Snelder, D.J. and Lasco, R.D. (eds), *Smallholder Tree Growing for Rural Development and Environmental Services: Lessons from Asia*. Springer, Berlin, pp. 453–485.
Rudel, T.K., Oliver, T.C., Moran, E., Achard, F., Angelsen, A., Xu, J. and Lambin, E. (2005). Forest transitions: towards a global understanding of land use change, *Global Environmental Change* 15, 23–31.
Santos, M.F. (2007). Using native timber trees for recovering degraded landscapes in the philippines: social, *Biophysical and Economic Assessment of Agroforestry Systems Practised by Smallholder Farmers*. University of Cordoba, Spain.
Santos, M.F. and van Noordwijk, M. (2009). Trade-offs analysis for possible timber-based agroforestry scenarios using native trees in the Philippines, *Agroforestry Systems* 76, 555–567.
Santos, M.F., Navarro, R.M., Mulia, R. and van Noordwijk, M. (2010). Allometric equations based on a fractal branching model for estimating aboveground biomass of four native tree species in the Philippines, *Agroforestry Systems* 78, 193–202.
Schute, A. (2002). *Rainforestation Farming: Option for Rural Development and Biodiversity Conservation in the Humid Tropics of Southeast Asia*. Shaker Verlag, Germany.
Shimamoto, M., Ubukata, F. and Seki, Y. (2004). Forest sustainability and the free trade of forest products: cases from Southeast Asia, *Ecological Economics* 50, 23–34.
Stark, M. (2003). *Natural Vegetative Strips for Soil Conservation on Sallow Calcareous Soils in Tabango*. World Agroforestry Centre, Los Baños, Philippines.
Tacher, T., Lee, D.R. and Schelhas, W. (1996). Farmer participation in reforestation incentive programs in Costa Rica, *Agroforestry Systems* 35(3), 269–289.
Tomich, T.P. and Lewis, J. (2001). *Deregulating Agroforestry Timber to Fight Poverty and Protect the Environment*. World Agroforestry Centre, Nairobi.
Valdez, R.B. (1991). *Improved Reforestation Technologies in the Philippines*. Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, Los Baños, Philippines.
Van Noordwijk, M. (1996). A simple model to quantify mulch and shade effects, in Ong, C.K. and Huxley, P.A. (eds), *Tree-Crop Interactions – A Physiological Approach*. CAB International, Wallingford, pp. 51–72.
Van Noordwijk, M. (1999). *Functional Branch Analysis to Derive Allometric Equations of Trees, Modelling Global Change Impacts on the Soil Environment*. World Agroforestry Centre, Bogor, Indonesia.
Van Noordwijk, M., Lusiana, B. and Khasanah, N. (2004). *WaNuLCAS 3.1. A Model of Water Nutrient and Light Capture in Agroforestry Systems*. World Agroforestry Centre, Bogor, Indonesia.
Van Noordwijk, M., Roshetko, J.M., Murniati, M., Angeles, M.D., Suyanto, S., Fay, C. and Tomich, T.P. (2008a). Farmer tree planting barriers to sustainable forest management, in Snelder, D.J. and Lasco, R.D. (eds), *Smallholder Tree Growing for Rural Development and Environmental Services: Lessons from Asia*. Springer, Berlin, pp. 427–449.
Van Noordwijk, M., Suyamto, D.A., Lusiana, B., Ekadinata, A. and Hairiah, K. (2008b). Facilitating agroforestation of landscapes for sustainable benefits: tradeoffs between carbon stocks and local development benefits in Indonesia according to the FALLOW model, *Agriculture Ecosystems and Environment* 126, 98–112.
Vosti, S.A., Witcover, J., Gockowski, J., Tomich, T.P., Carpentier, C.L., Faminow, M., Olivera, S. and Diaw, C. (2000). *Socioeconomic Issues Linked with the Best Bet Land Use System*. World Agroforestry Centre, Nairobi.

Appendix I

Example of input data (tradable inputs and labour requirements) required to elaborate farm activity budgets for each land use system.

Input	Land use system				
Item (unit)	Maize monocrop	100 trees intercrop	200 trees intercrop	400 trees intercrop	800 trees intercrop
Tradable inputs					
Fertiliser (urea) (kg/ha)	196.0	186.0	176.0	166.0	157.0
Fertiliser (TSP) (kg/ha)	133.0	124.0	117.0	111.0	104.0
Seeds maize (kg/ha)	40.0	38.0	36.0	34.0	32.0
Tree seedlings (seedlings/ha)	0.0	100.0	200.0	400.0	800.0
Labour					
Land preparation (ps-day/ha)	7.0	7.0	7.0	7.0	7.0
Plough (ps-day/ha)	30.0	28.5	27.0	25.5	24.0
Plant maize (ps-day/ha)	50.0	47.5	45.0	42.5	40.0
Plant trees (ps-day/ha)	0.0	2.0	4.0	8.0	16.0
Weed maize (ps-day/ha)	16.0	16.0	16.0	16.0	16.0
Fertilise maize (ps-day/ha)	4.0	3.8	3.6	3.4	3.2
Harvest maize (ps-day/ha)	4.0	3.8	3.6	3.4	3.2
Harvest trees (ps-day/ha)	0.0	20.0	40.0	80.0	160.0

Appendix II

Prices and macroeconomic assumptions used for PAM analysis.

Assumptions	Observations/sources	Rate (unit)
Social discount rate	= Inflation rate (September 2006)	5.7 (%)
Private discount rate	= 2 × inflation rate	11.4 (%)
Foreign exchange rate	US $ to PhP (September 2006)	50.4 (PhP)
Commodity policies		
Timber export tax	Department of Environment and Natural Resources	25.0 (%)
Timber margin share	Transportation and transactions cost	25.0 (%)
Domestic subsidies	To tradable purchased inputs (ie seeds, fertiliser)	0.0 (%)
Commodity prices		
Timber social price	Department Environment and Natural Resources	2819.6 (PhP/m^3)
Timber private price	= Social price−export taxes−margin share	1409.8 (PhP/m^3)
Maize social price	FAOSTAT data website	6.6 (PhP/kg)
Maize private price	= to social price	6.6 (PhP/kg)
Urea social price	FAOSTAT data website	18.0 (PhP/kg)
Urea private price	= to social price	18.0 (PhP/kg)
TSP social price	FAOSTAT data website	16.0 (PhP/kg)
TSP private price	= to social price	16.0 (PhP/kg)
Cost of labour		
Social wage	Minimum legislated wage rate	100.0 (Php/ps-day)
Private wage	= to social wage	100.0 (Php/ps-day)