Topic 3: The contribution of plantation and agroforestry to rural livelihoods

Smallholder maize-timber agroforestry systems in Northern Mindanao, Philippines: Profitability and contribution to the timber industry sector

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SUMMARY

In the Philippines, when prices of fast growing timber trees were high, many smallholders engaged in tree farming. Although in recent years a price decline due to market saturation has made tree farming less profitable, farmers are still interested in tree farming. To provide farmers with information based on empirical farm data, the profitability of two agroforestry systems with fast-growing timber trees and maize farming was investigated in northern Mindanao, Philippines. The agroforestry systems consisted of trees at close spacing (2 x 2,5 m) and wide spacing (1 x 10 m) with maize intercropped. The financial returns of both systems were compared with maize –mono-cropping. Timber source and use surveys conducted during the study indicate that farmers are not the only beneficiaries of their timber production activities. Many timber processors and wood-based industries are now relying on farm-grown trees for their supply. This paper also provides evidence of the increasing share of farm-grown timber to the wood industry, demonstrating the importance of smallholder timber production systems to meet domestic wood demand.

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INTRODUCTION

Since 1950, the forest area in the Philippines have disappeared at a rate of 2,2% annually. By 1987 only 6,6 million hectares of the country (i.e., 22% of the total land area) remained forested (Kummer 1992). Rapid deforestation has had dramatic economic and environmental consequences. It is estimated that 5.1 million hectares (i.e., 17% of the country's land area) are grasslands dominated by *Imperata cylindrica* (Garrity, et al., 1997). The forestry sector's contribution to the GDP has dropped from 12,5% in 1970 to just 2,3% in 1988 (PCARRD 1994) and 1,3% in 1990 (ADB 1994). The Philippines is now a net importer of timber (ITTO 1996). Importation is draining the country's foreign currency reserves at a rate of 14 billion pesos per year (Orejas 2002).

For more than three decades, tree planting has been promoted as the solution to the negative effects of widespread forest destruction. However, many tree planting efforts have had limited success. Timber License Agreement (TLA) holders did not significantly contribute to the reforestation efforts[1] due to corruption and control of TLAs by the political elite (Vitug 1993). Large government and foreign donor-funded reforestation and industrial plantation programs over large tracts of land created social conflicts due to farmer evictions and imposed restriction on farmers' livelihood activities on land they traditionally managed (Carandang and Lasco 1998; Lasco, Visco et al. 2001; LTD 2001). In addition, the wood industries associated with industrial forest plantations have struggled for economic survival (Inquirer 2000). As with other tree crops, such as coffee, cacao and rubber, scale economies may not exist in the production of timber since "neither large-scale machinery nor central management is required for the production of these tree crops" (Hayami, et al., 1993; Barr 2002). Social forestry programs and initiatives that started in the early 70's have not been more successful. According to Pascicolan (1996), as cited in Pascicolan, et al., (1997), between 1988 and 1992 the Contract Reforestation Program successful reforested only 10% of its 225,000 ha target. The program was very expensive to implement, and its assumptions that the mere participation of rural communities in planning and implementation of time-framed, target-oriented programs would be sufficient for success proved too simplistic.

In contrast, as a result of favorable market conditions and the promotion of a tree planting culture among upland farmers, during the past three decades smallholder tree farming has spontaneously emerged as a profitable farm enterprise and as a viable alternative to industrial forest plantations and costly government-driven reforestation programs (Garrity and Mercado 1993) (Pascicolan, et al., 1997). Paradoxically, small-scale tree farms in the Philippines were first promoted in the early 70's under the smallholder tree farming contract scheme supported by PICOP[2]. Tree farms developed under this scheme quickly spread. In 1997, there were 15,000 has of tree farms located nearby PICOP's mill site and another 29,000 hectares further away but

[1] TLA holders were required to reforest an area of denuded land equivalent to that selectively logged and since 1981, to engage in industrial tree plantation (ADB 1994).

[2] The Paper Industries Corporation of the Philippines (PICOP, Inc.) was one of the first major industrial forest plantation initiatives established to supply a pulp and paper mill sited at Bislig, Surigao del Sur. From 1972 up to 1994, a plantation of 33,200 hectares of the fast-growing species *Paraserianthes falcataria* and *Eucalyptus deglupta* were established in its forest concession area (ADB 1994); (Jurvélius 1997).

selling wood to PICOP (Jurvélius 1997). The high price of timber and the demonstration effect of PICOP's tree farming scheme, as well as the development of other successful tree planting programs, supported the spread of tree farming throughout the country.

Unfortunately, tree farming has been promoted on the promise of huge economic returns, based on overoptimistic yields of fast-growing trees in favorable tropical humid conditions and unrepresentatively high timber prices at specific times and locations[3]. In the past few years, lower than expected returns from tree farming, particularly with *Gmelina arborea* R.Br (gmelina) and *Paraserianthes falcataria* (L.) Nielsen (falcata), has caused disenchantment among upland farmers (Caluza 2002). As planted trees reached harvestable age, prices fell drastically due to market saturation. In 1997, the price of gmelina on stumpage averaged PhP. 4 per board foot (bd.ft.), (i.e., 33 US $ m^{-3}), a sixty percent (60%) decline with respect to prices in the early 90's. Moreover in the smallholder context, timber yields may be lower than predicted as a result of adverse soil conditions and farmers' poor management practices (e.g., excessive pruning and lack of thinning).

In spite of these setbacks, a field survey conducted in the upland municipality of Claveria, northern Mindanao among 68 farmers who had planted timber trees, revealed that 35% wanted to expand their tree plantation and were interested in trying new timber species (Bertomeu, forthcoming). In addition to the benefits provided to rural families such as fuelwood, construction materials, protection against erosion, shade and shelter, farm-grown timber is taking an increasing share of the timber industry and trade in the Philippines. The existence in Region 10[4] of 135 mini-sawmills[5] exclusively supplied with farm-grown timber (DENR 1996) demonstrates the extent and importance of tree farming in the region and provides evidence that growing timber trees on farms is still considered a viable livelihood alternative and an activity with an importance to the wood industry sector.

This paper has two objectives. First, I aim to provide a more realistic assessment of the profitability of smallholder timber tree farming systems on sloping lands based on data from on-farm trials established in the upland municipality of Claveria, Misamis Oriental, Philippines. Secondly, evaluate the contribution of smallholder timber production systems to rural livelihoods and the national economy by presenting evidence of the increasing importance of farm-grown timber to sustain and develop the country's wood industry and trade.

[3] A local newspaper said that one hectare with Eucalyptus deglupta could yield "PhP 14,000 per tree or PhP 10.5 million per hectare" (Fonollera 1996). The catching saying "Kahoy karon, bulawan ugma" (Trees today, gold tomorrow) common among Philippinos in northern Mindanao exemplifies the expectations put on tree farming.

[4] Region 10 of northern and central Mindanao is composed of the provinces of Misamis Oriental, Misamis Occidental, Bukidnon and Camiguin

[5] Mini-sawmill: a sawmill consisting of a single head rig with a flywheel diameter not exceeding 106 cm, a band saw blade with thickness not exceeding three (3) mm and width of not more than 27mm, with or without a carriage, and a daily rated capacity of no more than 18 cu.m. or 8000 board feet of lumber per 8 hour shift (DENR Memorandum Order 96-09)

MATERIALS AND METHODS

Description of the study site

The study was conducted in Claveria, an upland municipality located 42 km northeast of Cagayan de Oro City, in northern Mindanao. The municipality covers an area of 112,175 hectares, has a mountainous topography with 62% of the area having slopes of 18% or greater with elevation between 390-2000 m. a.s.l. (DTI and Engineers 1996). Average rainfall is 2,500 mm with a wet season from June to December (>200 mm rainfall per month) and a short dry season from March to April (<100 mm rainfall per month) (Kenmore and Flinn 1987). Soils are derived from volcanic parent material and classified as deep acidic (pH 3.9-5.2) Oxisols with texture ranging from clay to silty clay loams, with low available P, low CEC, high Al saturation and low exchangeable K (Magbanua and Garrity 1988). At lower elevations (400-700 m), maize (*Zea mays* L.) is the dominant crop, cultivated twice a year or in rotation with cassava (*Mahinot esculenta* Crantz) or upland rice (*Oryza sativa* L.)

Tomato and other vegetable cash crops are commonly grown on the higher elevations (700-900 m. a.s.l.). Average farm size is 3 hectares with farmers commonly cultivating two or more parcels of land.

In the past 50 years, land use in Claveria has experienced a rapid transformation from natural forests to grasslands to a mosaic of intensive cash and food cropping and perennial-based systems (Garrity and Agustin 1995). More recently, the use of grass strips of natural vegetation (NVS) along contours as a measure to control soil erosion has become common among farmers in the area. This practice is also the base for the incorporation of fruit and timber trees (Stark 2000)

Experimental approach

The performance of Gmelina (*Gmelina arborea* R.Br.)- and Bagras (*Eucalyptus deglupta* Blume)-intercropped with maize were studied and compared to that of maize mono cropping. Two timber agroforestry systems were chosen based on farmers' common practice of planting trees either in woodlots at close spacing (e.g., 1 x 2m; 2 x 2 m) or in lines 6 to 7 m. apart (e.g., 1 x 6 m).

The study was conducted in researcher-designed and –managed on-farm trials established in a randomized complete block design with 3 treatments and 4 replications. Treatments consisted of:

Farmers' practice:

- T_1 (NVS): maize mono cropping between narrow strips of natural vegetation 10 meters apart.
- T_2 (Block-fallw): timber trees in woodlot or blocks at 2 x 2,5 m (2000 stems/ha), with maize inter-planted in the 2,5 meter alleys until canopy closure.

"Improved" practice:

- T_3 (Hedg-cont crop): timber trees on hedgerows 1 x 10 m apart (1000 stems/ha), with maize intercropping in the 10-meter wide alleys.

Block plots contain 9 lines of trees with 8 trees per line (i.e., 72 trees); and hedgerow plots contain 3 lines of tree with 16 trees per line (i.e., 48 trees). Fifteen (15) rows of maize were planted on each of the two alleys of the NVS and Hedgerow plots. In the Block plots, three (3) rows of maize were planted in the 8 alleys between tree lines.

Plots were 300 m^2 (15 x 20 m), with a centered net plot of 6 meters, a border of 4,5 meters on both sides of the net plot and a guard area of 8-9 meters between plots to avoid the influence on observations of trees from adjacent plots.

It was hypothesized that with the “improved” practice of planting trees on hedgerows at wide distance (i.e. 8-10 m):

- Farmers would benefit from the reduction of area lost to trees.
- Farmers would be allowed to plant crops on the alleys between rows of trees for longer period.
- Trees would grow faster than those planted in blocks because of the more intensive management and better light regime.

Research plot management

Tree seedlings were raised in a nursery and planted on September-October 1997. Maize cropping started on October 1997 and continued, in the NVS and hedgerow treatments, for 7 cropping seasons until the last harvest on January 2001. Only 3 crops were planted in the block system before canopy closure. Contour hedgerows of natural grass were established in the research plots leaving a 50 cm-wide unplowed strip along the contour. Every year, a wet season of maize crop was planted in May and harvested in early September, followed by a dry season crop sown in early October and harvested in January. Draught animal power was used for land preparation, consisting of two plowing and one harrowing operation. All other maize farming operations (i.e., fertilizing, weeding) were performed manually following local practices. Every cropping season, a hybrid maize variety, Pioneer 3014, was sown into furrows at a spacing of 30 cm along each row and 60 cm between rows. Each maize crop was fertilized with the recommended dose of 80-30-30 kg NPK ha^{-1}. Phosphorus (Solophos 0-18-0) and potassium (Muriate of Potash 0-0-60) fertilizer and the insecticide-nematicide Furadan 3G were applied at sowing. Maize re-sowing was done 5 to 7 days after emergence (DAE). Nitrogen (Urea 46-0-0, 46% N) was applied as equal split doses by side dressing 15 and 30 DAE. After nitrogen application, interrow cultivation was performed to cover the fertilizer with soil and as a weed control measure. Manual hand weeding was also done as needed, usually one to two weeks after second interrow cultivation.

Tree seedlings were planted just above the grass strips established during land preparation of the first crop. Mortality was replaced 3 months after planting. Between January to May 1998, trees had to be watered twice a month due to the severe drought caused by El Niño. In June-July 1998, after the dry spell, mortality was replaced in order to keep plot conditions homogenous. Trees replaced after the drought were not included in the calculations of the tree parameters presented below.

Ringweeding was conducted at planting. Subsequent weeding operations consisted of two grass slashing per cropping season for trees in hedgerows. Trees in blocks were weeded only through the third year.

Pruning was done so as to leave a live crown ratio (LCR) of 40-60%. One singling and form pruning was conducted to retain a single stem and improve form when the trees were 1 year old. Branch pruning operations were performed three times during the four-year period. A 50% intensity thinning was conducted at 34 months after planting.

Data collection and analysis

Maize grain yield data was taken row by row from a 6 meter-wide centered net plot. At harvest, fresh grain and total biomass were measured and two plant samples were taken from each of the upper, middle and lower alley zones. Grain yield at 14% moisture content was obtained after oven-drying the sub-sample.

Diameter at breast height (dbh) and tree height were recorded twice a year until the age of 54 months. At the age of 40 and 48 months, diameter at 8 feet height was also recorded in order to calculate taper (i.e., the rate of change of diameter with height). Average dbh of *Gmelina* at the end of the rotation was estimated to be 30-35 cm based on measurements on 170 logs at 7 sawmills.

A survey among 16 mini-sawmill operators and interviews with 3 wood processors from Cagayan de Oro and neighboring municipalities were conducted to collect data on supply and demand, prices, minimum merchantable diameter and uses and marketing. Other data of interest were taken from secondary sources and available statistics.

Financial returns of the systems were analyzed by using a spreadsheet to calculate the net benefits through an 8-year and a 12-year tree rotation period for Gmelina and Bagras respectively. For each system, the net present value (NPV) was calculated at discount rates of 7, 15 and 20% and assuming two timber yields and three price scenarios.

RESULTS

Maize grain yield

Maize grain yield in the wet season crop were consistently higher than those of the dry season crop (Table 1) (Table 2). Yields of the first dry cropping season do not seem negatively affected by the dry spell caused by El Niño. On the contrary, the occurrence of the drought during the later part of the cropping season (December 1997) could have benefited grain development and maturity.

In maize mono cropping (NVS), an average grain yield of 5 tons ha-1 for the wet season crop and 3 tons ha-1 for the dry season crop were assumed in the calculations of returns from year 5 until tree harvest.

The break-even maize yield in hedgerow intercropping, estimated as the yield that is required to cover the costs of maize and tree farming, was 3,0 ton ha-1 and 2,0 ton ha-

1 for the wet and dry season crop respectively. After the second cropping year, wide-spaced gmelina trees reduced maize grain yield almost a 50% over the yield of the first year. In this system, maize farming produced negative returns in all cropping after the second wet season crop (Table 1). Bagras proved to be less competitive than gmelina, producing maize yields below the break-even only in the last cropping season (Table 2).

Table 1. Maize grain yield (ton/ha) in two agroforestry systems with *Gmelina arborea* and maize mono cropping

	Wet season crop				**Dry season crop**		
Year	**NVS**	**Hedgerow**	**Block**		**NVS**	**Hedgerow**	**Block**
1997	4.9*	4.9*	4.9*		3.0	2.7	3.0
1998	5.7	4.8	5.0		2.5	1.7	0.3
1999	4.6	2.6			3.2	1.4	
2000	4.5	2.5			2.8	1.0	

Table 2. Maize grain yield (ton/ha) in two agroforestry systems with *Eucalyptus deglupta* and maize mono cropping

	Wet season crop				**Dry season crop**		
Year	**NVS**	**Hedgerow**	**Block**		**NVS**	**Hedgerow**	**Block**
1997	5.6*	5.6*	5.6*		3.4	3.4	3.2
1998	6.9	6.3	5.6		3.2	3.1	1.6
1999	5.3	4.0			4.1	2.6	
2000	4.7	3.7			3.0	1.7	

*The profitability analysis assumes that the first crop planted is that of the wet season crop (May-June). Trees are planted after the harvest of the first crop and before sowing the first dry season crop. Since research trials started with the planting of trees and the dry season crop on September-October 1997, grain yield for the first cropping season was assumed to be the same in all systems and equal to the average wet season crop in the NVS plots.

Three maize crops were planted in the narrow alleys of the Block planting system before canopy closure. However, the third crop was greatly reduced in the blocks with gmelina and below the break-even yield in the blocks with bagras. It should be also noted that the high grain yield of 5 and 5.6 tons ha^{-1} in the wet season crop of 1998 (second crop) was due to the fact that during the first eight months after planting tree growth was severely reduced because of the extreme drought occurrence, attaining only an average height of 1-1.5 m. In an normal year, trees would have reached an average height of 2 to 3 meters six months after planting, reducing the maize yield of the second crop to an estimated 1.5-2 tons ha^{-1}. Therefore, after planting trees in block arrangement, farmers could expect to grow only 1 crop with average yields and a second crop with reduced yields close to the break-even.

As farmers would not plant maize when yields fall below the break-even, a new hedgerow-fallow (hedg-fallw) system in which maize is not planted when producing negative returns, was included in the profitability assessment (Table 3). Gmelina

showed to be so competitive that even if tree lines are planted 10 meters apart, after tree planting only two cropping would produce positive returns. Planting Bagras on hedgerows, however, allowed for 6 continuous cropping after tree planting (Table 3).

In spite of the negative returns of continuous intercropping between gmelina tree hedgerows (Hedg-cont crop), the system was included in the cost-benefit analysis for the purpose of comparison with the improved hedgerow-fallow (Hedg-fallw) and block planting system (Block-fallw).

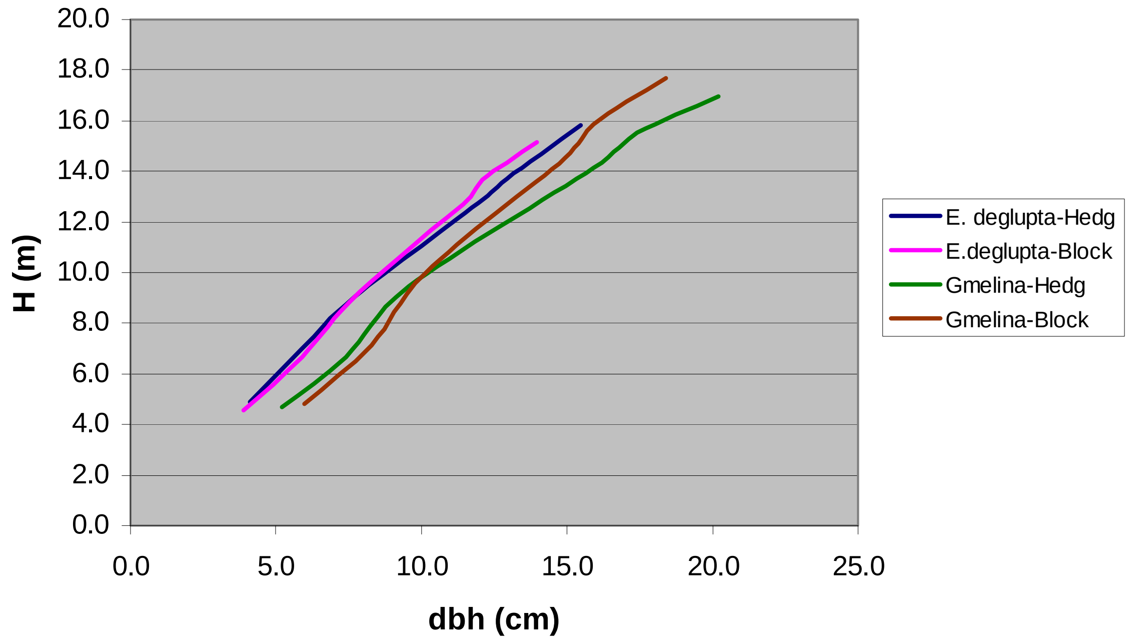
Table 3. Maize grain yield (ton/ha) in Hedgerow-fallow system (Hedg-fallw)

	Maize-Gmelina arborea		Maize-Eucalyptus deglupta	
Year	**Wet season crop**	**Dry season crop**	**Wet season crop**	**Dry season crop**
1997	4.9	2.7	5.6	3.4
1998	4.8	0.0	6.3	3.1
1999	0.0	0.0	4.0	2.6
2000	0.0	0.0	3.7	0.0

Tree growth and yield

At the age of 54 months, trees planted on hedgerows attained a larger dbh than trees planted on blocks(Fig.1).

Fig. 1. Diameter and height growth of *Eucalyptus deglupta* and *Gmelina arborea* in hedgerow and block planting arrangement at the age of 54 months



To further investigate the effect of growing trees at wide spacing on dbh growth and thus on timber yield, a paired T-test was conducted to compare growth in dbh between trees planted on hedgerows and blocks. Although both species showed increasing difference in average dbh with age, only Gmelina showed convincing evidence that at the age of 4,5 years, trees on hedgerows attain a larger dbh than trees planted on blocks (Table 4 and 5). The plausible values for the difference given by the 95% confidence interval for the mean are (0.6, 5.2) for gmelina and (-0.4 and 4.1) for bagras.

Table 4. Increased dbh growth with age of *Gmelina arborea* in hedgerow as compared to block planting arrangement

	17 mos.		**34 mos.**		**54 mos.**	
		dbh		**dbh**		**dbh**
Tree arrangement	**N**	**(cm)**	**N**	**(cm)**	**N**	**(cm)**
Hedgerows (1 x 10m)	147	5.0	74	14.1	65	19.9
Blocks (2 x 2,5 m)	156	5.7	86	12.7	70	17.1
SED		0.36		0.43		0.72
F-test probability		0.146		0.052		0.028

N: total number of trees

SED and p-values have been correctly calculated based on plot averages, not individual tree values

Table 5. Suggestive but inconclusive evidence of increased dbh of *Eucalyptus deglupta* planted on hedgerows as compared to blocks.

	17 mos.		**34 mos.**		**54 mos.**	
		dbh		**dbh**		**dbh**
Tree arrangement	**N**	**(cm)**	**N**	**(cm)**	**N**	**(cm)**
Hedgerows (1 x 10 m)	141	4.1	79	10.6	61	15.6
Blocks (2 x 2,5 m)	139	3.8	82	10.4	62	13.7
SED		0.26		0.33		0.70
F-test probability		0.438		0.451		0.079

N: total number of trees

SED and p-values have been correctly calculated based on plot averages, not individual tree values

At the age of 4 years, gmelina trees planted on hedgerows also showed a larger taper (2 cm) than trees on blocks (1.5 cm.). However, taper of bagras was similar in both arrangements (0.8-1 cm) and notably smaller as compared to gmelina. Therefore, merchantable height was significantly larger in bagras as compared to gmelina (Table 6).

A dbh of 30-35 cm at harvest and a minimum merchantable diameter of 14 cm were calculated from the measurement of gmelina logs at the sawmills. It was not possible to take measurements on harvested bagras as most planted trees in the area have not reached maturity yet and therefore it is seldom found in sawmills. With these parameters, timber volume at the end of an eight-year rotation period was estimated to range from 60 m^3 ha^{-1} to 110 m^3 ha^{-1} for gmelina and 146 to 185 m^3 for bagras (Table 6). The timber yields in the low productivity scenarios are similar to those used in the financial analysis of tree plantations by the Department of Environment and Natural Resources (DENR-ERDB 1998).

Table 6. Harvest scenarios for *Gmelina arborea* and *Eucalyptus deglupta* at the end of an 8-year and a 12-year rotation period respectively.

Timber yield scenarios		N	Dbh (cm)		H_m (m)		V_m (m^3/ha)	
		(stems ha^{-1})	Hedg	Block	Hedg	Block	Hedg	Block
G. arborea	Low	250	30	27	8.6	9.1	69	61
	High	250	35	32	11.0	12.3	110	104
E. deglupta	Low	250	28	28	15.0	15.0	146	146
	High	250	30	30	17.0	17.0	185	185

H_m: Merchantable height, assuming a small-end diameter of 14 cm and taper as reported in this paper.

V_m: merchantable volume using the tree volume equations:

For Gmelina arborea: $\text{Log } V_m = -3.8579 + 1.6844 \log \text{Dbh} + 0.8671 \log H_m$ (Virtucio 1984).

For Eucalyptus deglupta: $\text{Log } V_m = 0.030318 + 2.049154 \log_{10} \text{Dbh} + 0.739098 \log_{10} H_m$ (Tomboc 1976)

Profitability of timber-based agroforestry systems

The profitability of the systems studied is examined for the different timber yield scenarios and in the event of changes in the discount rate applied and the stumpage price. Formal and informal credit and cash lending schemes among farmers in Claveria, suggest that discount rates of 10-20% would be appropriate to evaluate and compare the profitability of alternative tree farming systems against existing mono-cropping practices. A stumpage price of 4PhP $bdft^{-1}$ (1,700 PhP m^{-3}) represents the current average price (low price scenario); 5PhP $bdft^{-1}$ (2,100 PhP m^{-3}) is the price that some traders are willing to pay for better quality timber[6] (medium price scenario); and 7 PhP $bdft^{-1}$ (2,960 PhP m^{-3}) the price in the year 1995, before the sharp price decline of timber prices (high price scenario).

The cost-benefit analysis for the low timber yield scenario and current low stumpage price of 4 PhP $bdft^{-1}$ (i.e., 33 US$ m^{-3}, considering current exchange rate of 1 US$ = 51 Philippine Peso PhP) shows that maize mono-cropping is more profitable than agroforestry with gmelina even at a discount rate as low as 4% (Table 7) and as profitable as bagras-maize intercropping at a 7% discount rate (Table 8).

[6] The survey conducted among mini-sawmill owners and lumber dealers revealed that a 50% would pay a stumpage price 1-2 PhP $bdft^{-1}$ higher than the average 4 PhP $bdft^{-1}$ for straight logs, which are 8 feet long and 15-20 cm in the small-end diameter.

Table 7. Net present value (NPV) (PhP ha^{-1}) of maize mono-cropping and maize-gmelina agroforestry (low timber yield scenario, low timber price)

		Agroforestry with *Gmelina arborea*		
Cost and Benefits	**Maize monocrop (NVS)**	**Hedg-cont crop**	**Hedg-fallw**	**Block-fallw**
Benefits				
Maize grain yield	351,954	104,969	59,368	61,706
Gmelina Timber	0	116,850	116,850	102,874
Total	351,954	221,819	176,218	164,580
Costs				
Inputs maize cultivation	110,244	48,997	18,374	14,699
Labor maize cultivation	111,336	49,572	19,611	17,626
Tree establishment	0	3,699	3,699	7,397
Tree management	0	1,328	1,928	3,493
Total	221,581	103,596	43,611	43,215
NPV at 4%	111,779	87,919	100,983	93,531
NPV at 7%	100,629	71,304	83,492	78,128
NPV at 15%	78,966	43,133	53,373	51,576
NPV at 20%	69,512	32,913	42,163	41,673

1US $ = 51Philippine Peso (PhP) (exchange rate in December 2002)

Table 8. Net present value (NPV) (PhP ha^{-1}) of maize mono-cropping and maize-bagras agroforestry (low timber yield scenario, low timber price)

		Agroforestry with Eucalyptus deglupta		
Cost and Benefits	**Maize monocrop (NVS)**	**Hedg-cont crop**	**Hedg-fallw**	**Block-fallw**
Benefits				
Maize grain yield	536,050	150,002	140,068	69,065
Eucalyptus Timber	0	247,201	247,201	247,201
Total	536,050	397,204	387,269	316,266
Costs				
Inputs maize cultivation	159,242	48,997	42,873	14,699
Labor maize cultivation	160,748	49,572	44,316	17,626
Tree establishment	0	5,499	5,499	10,997
Tree management	0	1,328	1,328	3,493
Total	319,990	105,396	94,016	46,815
NPV at 4%	176,032	197,472	198,758	176,412
NPV at 7%	153,839	151,772	152,952	131,585
NPV at 15%	114,688	85,719	86,670	67,524
NPV at 20%	99,247	65,886	66,723	48,736

A price increase of 1 PhP bdft^{-1} (i.e., from 33 US$ m^{-3} to 41 US$ m^{-3}) would make gmelina hedgerow-fallow as profitable as maize monocropping and bagras-maize agroforestry more profitable than maize monocropping at a 7 % discount rate (Table 9). With a price increase to 1995 levels, 7PhPbdft^{-1} (i.e., 58 US$ m^{-3}) the agroforestry-fallow systems with both gmelina and bagras are more profitable at a 15% discount rate but not at 20% (Table 9).

Table 9. Sensitivity analysis (PhP ha^{-1}) showing the impact of changes in timber stumpage price on the NPV at 7, 15 and 20% discount rate (low timber yield scenario)

System	Stumpage price (5 PhP bdft^{-1})				Stumpage price (7 PhP bdft^{-1})		
	7%	**15%**	**20%**		**7%**	**15%**	**20%**
Gmelina agroforestry							
Mz-monocropping (NVS)	100,629	78,966	69,512		100,629	78,966	69,512
Hedg-cont crop	88,306	52,683	39,707		122,310	71,782	53,294
Hedg-fallw	100,494	62,923	48,957		134,498	82,022	62,544
Block-fallw	93,096	59,983	47,654		123,033	76,798	59,617
Eucalyptus agroforestry							
Mz-monocropping (NVS)	153,839	114,688	99,247		153,839	114,688	99,247
Hedg-cont crop	179,212	97,270	72,818		234,092	120,372	86,680
Hedg-fallw	180,392	98,221	73,654		235,273	121,323	87,517
Block-fallw	159,025	79,075	55,667		213,905	102,177	69,530

At current low prices, increasing gmelina timber yields from 69 m^{3} ha^{-1} to 110 m^{3} ha^{-1} would make agroforestry more profitable than maize farming at 7% discount rate and of similar profitability at 15%. However, a timber yield increase of Bagras from 146 to 185 m^{3} ha^{-1} would not make agroforestry more profitable than maize farming at 15% discount rate (Table 10).

With high timber yields, in the event of a stumpage price increase of 1PhP bdft^{-1}, agroforestry with gmelina would almost be as profitable as maize monocropping at 20% discount rate. Bagras-maize intercropping will only provide similar returns to maize monocropping at 15% discount rate (Table 10).

Table 10. Sensitivity analysis (PhP ha^{-1}) showing the impact of changes in timber stumpage price on the NPV at 7, 15 and 20% discount rate (high timber yield scenario)

System	Stumpage price (4 PhP bdft^{-1})				Stumpage price (5 PhP bdft^{-1})		
	7%	**15%**	**20%**		**7%**	**15%**	**20%**
Gmelina agroforestry							
Mz-monocropping	100,629	78,966	69,512		100,629	78,966	69,512
Hedg-cont crop	112,241	66,127	49,271		139,477	81,424	60,154

Hedg-fallw	124,428	76,366	58,521		151,664	91,664	69,404
Block-fallw	121,063	75,692	58,830		146,766	90,128	69,100
Eucalyptus agroforestry							
Mz-monocropping	153,839	114,688	99,247		153,839	114,688	99,247
Hedg-cont crop	180,696	97,895	73,193		215,367	112,490	81,950
Hedg-fallw	181,876	98,846	74,029		216,547	113,440	82,787
Block-fallw	160,508	79,699	56,042		195,179	94,294	64,800

Farm-grown timber: increasing the share of the wood industry in the Philippines

In 1996, there were 135 mini-sawmills in Region 10 of Northern Mindanao (DENR 1996). The 16 small-scale sawmills (SSS) surveyed had a total of 65 operational mini-sawmills, with an average of 2 mini-sawmills per SSS. Interestingly, the Philippine Year Book 1999 only acknowledges the existence in 1996-1997 in Region 10 of 2 active sawmills with an annual log requirement of 56,800 m^3 (NSO 1999).

According to (ITTO 1996), in 1995 there were 11,550 employees of all processing mills (sawmills, veneer and plywood mills) in the country. A conservative estimate of people directly employed[7] by the mini-sawmill industry in Region 10 in 1996 is that of 675, which represents a 6% of the national work force reported by International Tropical Timber Organization (ITTO).

Mini-sawmills are mainly supplied with logs of *Gmelina arborea* (gmelina) and *Paraserianthes falcataria* (falcata) mostly grown by smallholder farmers. Other species milled, though in smaller volumes, include *Acacia mangium* (mangium), *Swietenia macrophylla* (mahogany), *Eucalyptus deglupta* (Bagras), and *Spathodea campanulata* (African tulip). Gmelina is mostly purchased on stumpage from municipalities within the province, whereas falcata is bought in truckloads coming from the neighboring regions of Agusan and Surigao, showing that it is economically viable for the sawmills to procure supplies from as far as 200 kilometers.

According to the survey respondents, in a regular 8-hour working day a mini-sawmill produces between 700-1,000 bd.ft. of sawntimber of gmelina or 1,000-1,600 bd.ft of falcata, with an average recovery rate of 45%. Considering that of the 16 SSS visited only 45% operates continuously and using an average production of 1,000 bdft of sawn wood per mini-sawmill per day, an estimated 45,000 to 53,617 m^3 of farm-grown sawn wood was produced every year in Region 10 since 1996. With the reported average recovery rate of 45%, a conservative estimate of smallholder log production in Region 10 is that of 65,250 - 77,745 m^3 yr^{-1}. Considering the existing sawmill capacity and assuming a continuous operation of mini-sawmills, the potential annual log utilization and sawn timber production is estimated to be 111,064 m^3 and 76,596 m^3 respectively. If compared to the available statistics of the sawn wood exports from the Cagayan de Oro port (table 11), it can be concluded that these are very conservative estimates of the contribution of smallholder farmers to the wood industry in the region.

[7] This estimate do not consider the many people involved in harvesting, transporting, further processing and marketing.

Table 11. Exports of Falcata sawnwood from Cagayan de Oro Port

	Volume*	Value
Year	(m^3)	(million PhP)
1994	22,863	87.218
1995	30,971	142.614
1996	42,361	237.924
1997	25,175	165.421
1998	1,795	43.144
1999	113	1.127

Source: Regional Statistical Year Book 2000, Neda Region X and 1995-96 Misamis Oriental Provincial Socio-economic Profile.

*Volume adjusted from weight assuming the conversion factor for sawn wood of 1.43 m^3/ton (ITTO 1996)

The yearly annual review assessment of the world tropical timber situation published by the International Tropical Timber Organization (ITTO) provides the best statistics available on the international trade of planted trees in the Philippines. Although a number of owners of SSS and several managers of medium size wood industries report exporting sawn timber of gmelina to other Southeast Asian countries, falcata is the only farm-grown timber specie that is reflected in the statistics. Considering that in the Philippines sawn wood exports are restricted to those arising from plantation forests or from imported logs (ITTO 1996), between 1995 to 1998 40 to 45% of the total sawn wood exports would come from the planted falcata trees, if the figures are correct (Table 12). Compared to domestic consumption, the exports of falcata sawnwood would represent a 7-10% of the total sawnwood consumed during the same years (Table 13). In the latest ITTO report, it is acknowledged that "as of 1999, logs coming from plantations made up to 70% of the log production of 712,000 m^3 ", or 500,000 m^3 of the total production.

Table 12. Large share of falcata sawn wood to total sawn wood exports

	Volume exported (x 000 cu.m.)		
Year	Total*	Falcata*	%
1994	38	47	
1995	84	44	52
1996	145	67	46
1997	141	63	45
1998	41	15	37
1999	69	4	6
2000	120	15	13
2001	142	nd	

*Source: ITTO Annual review and assessment of the world tropical timber situation

Table 13. Falcata sawn wood exports as compared to domestic sawn wood consumption

	Volume (x 000 cu.m.)		
Year	**Domestic consumption**	**Falcata exports**	**%**
1994	668	47	7
1995	580	44	8
1996	735	67	9
1997	622	63	10
1998	477	15	3
1999	600	4	1
2000	366	15	4
2001	321	nd	

*Source: ITTO Annual review and assessment of the world tropical timber situation

DISCUSSION

At current low timber prices (i.e., stumpage price of 4 PhPbdft^{-1}), the agroforestry systems studied would be an alternative to maize monocropping at a 10-12% discount rate, only if timber yields are above 100 m^3 ha^{-1} for short-rotation trees (8-9 years) and around 200 m^3 ha^{-1} for trees with rotations of 10-15 years. Such timber yields could be realized by planting trees on lines at wide spacing, like the hedgerow system tested, rather than on blocks or woodlots. Hedgerow systems promote greater diameter growth as trees benefit from a better light regime and the fertilizer applied to the intercrop. Moreover, the tree hedgerow system also provides higher profitability than the block planting because of lower tree establishment and management costs and, in the case of bagras, higher returns from a longer intercropping period. With proper tree management practices (i.e., pruning and thinning), which are required to attain higher timber yields, farmers could also benefit from a timber price increase, as the sawmill survey showed. If higher timber yields are combined with a price increase of 1 PhP bdft^{-1} (i.e., a stumpage price of 5PhP bdft^{-1}), gmelina-maize agroforestry systems would be more profitable than maize mono cropping at 15% discount rate and of similar profitability at a 20% discount rate. The analysis of intercropping system with bagras shows that longer tree rotations would make agroforestry almost as profitable as maize monocropping only at a 15% discount rate.

The present lower profitability of smallholder tree farming systems in the Philippines can be ultimately attributed, first, to the a past overemphasis on a few fast growing tree species and secondly, to “the promotion of tree planting without considering the many different kind of tree users and the many purposes for which trees are planted” (Raintree 1991). As in the case of *Eucalyptus* in India (Conroy 1993), in many parts of the Philippines the promotion and planting of trees such as gmelina or falcata have been so successful that a drastic price decline resulted as farm-grown timber saturated the market. In an attempt to increase the returns from timber-based agroforestry systems, many farmers are now shifting to higher-value trees such as bagras and

Swietenia macrophylla[8] (mahogany). In many upland landscapes of the Philippines, the ubiquitous mahogany demonstrates that farmers are not only interested on short rotation species but that they are willing to wait longer than what is commonly assumed.

Tree planting should not be promoted on the assumption of a uniform rural population. Rather, smallholder upland farmers are a very diverse group of rural dwellers with very different socio-economic conditions. Subsistence oriented farmers, whose main objective is food security and risk reduction, can not plant gmelina in close association with crops given its strong competitiveness. As the research trials showed, even if trees are as far as 10 meters, yields in alley crops are reduced below economic levels 2 cropping seasons after tree establishment. Instead, gmelina would be preferably planted on farm boundaries, home gardens or other farm niches away from cropped areas. However, for farmers with enough land to meet their basic needs, trees planted on blocks or on cropland may be an option for cash income, as savings to be used in case of emergency or to meet particular needs (e.g., to pay school fees). Tree farming systems may also be a better choice for those smallholders with off-farm employment or facing management and labor constraints (Saxena 1992) (Arnold and Dewees 1997). In the systems studied, labor inputs over a tree rotation period of 8 years were 70% higher in the maize mono-cropping than in the tree-fallow alternatives (Appendix 1). In the smallholder context, timber trees are also valued for many other reasons and therefore, profitability is not the only factor that determines adoption of tree planting (Scherr 1995) (Cramb 2000). In Indonesia smallholder farmers plant timber trees to i) produce tree products for home use and markets, ii) diversify the farm productivity, and iii) make better use of their labor, capital and land resources (Roshetko, et al., 2002). In Claveria, timber trees are planted to control erosion, restore soil fertility, for construction materials, land demarcation and aesthetics (Magcale-Macandog, et al., 1999).

Farmers are not the only ones seeking and testing new tree species suitable to their specific conditions. The wood industry is also actively looking for other tree alternatives in order to meet domestic demand and reduce their present dependence on imported timber. During the last few years, a plywood company near Cagayan de Oro City, has been testing the veneering potential of more than 30 tree species commonly-grown on farms. Of these, 5 native pioneer were identified as suitable for face and back veneer and several others for core stock. The company is also using falcata for core veneer, again demonstrating the market potential of trees grown on-farms (Bertomeu, forthcoming). These initiatives led by farmers and the industry to find new tree alternatives are an indication that facilitating access to a wider range of tree options could prove to be a simpler and more successful reforestation strategy that would satisfy the needs of farmers, the industry and the society.

The volume of farm-grown timber harvested, processed and traded in the past few years, proves the success of smallholder upland farmers in tree planting and marketing. Smallholder tree farms may have several advantages over other approaches to reforestation. Trees benefit from intercropping due to the fertilizer applied to crops, wider spacing and better light regime. (Jordan, et al., 1992) reported

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[8] *Swietenia macrophylla* King, is a highly prized timber tree native to central and South America. Trees planted on farms in the Philippines are harvested in rotations of 20-30 years and reach a market price as high as that of native timber.

that the Taungya system is best to reduce reforestation costs and to produce timber for the farmers and the industry. In Kenya, it is one the best strategies for tree establishment and survival (Tyndall 1996). On Imperata grasslands, high mean annual growth can be attained only with intensive establishment and management (Kosonen, et al., 1997). Early weed competition control can increase plantation survival as much as 90% and volume growth by more than 50% (Lowery, et al., 1993). Lower establishment costs, reduced risk of fire and more intense maintenance and management are the unique advantages of smallholders in tree planting (Garrity and Mercado 1993).

Unfortunately, existing policy disincentives constrain the establishment of tree farms. Although, recent legislation exempt owners of planted trees from paying forest charges, farmers are required to apply for a Certificate of Registration of the plantation and a Certificate of Verification to show that trees are ready to be harvested (GOLD 1998). Moreover, at the village level there exists a lot of confusion on whether fees have to be paid or not. Field inquiries reveal that many farmers are required to pay harvesting fees to local officials, although there is no legal basis for such fees. Incentives to encourage forest plantation establishment, like income tax holidays, tax and duty free importation of capital equipment, and exemption from contractors' tax (ITTO 2001), are better suited for industrial plantations and have limited application to smallholder farmer conditions. By favoring large industrial plantations such incentives function as de facto disincentives for smallholder timber producers. What is required in forestry policy is a paradigm shift that recognizes the legitimate role of smallholder farmers as contributors to national timber production (Noordwijk, et al., 2003).

CONCLUSIONS

In the past three decades in the Philippines, as natural forest became increasingly scarce, timber farming emerged as a profitable small farm enterprise. But in the past few years, timber prices collapsed as markets became saturated with large quantities of low and average quality timber from fast-growing trees. At current stumpage prices for fast-growing trees, smallholder timber agroforestry systems that produce low yields of timber are not a viable alternative to maize farming.

However, if productivity levels are increased to 100-110 m^3 ha^{-1} for short rotation trees (8-9 years) and to 180-190 m^3 ha^{-1} for trees with longer rotation (12-15 years), agroforestry systems provide a more profitable alternative to maize mono cropping at discount rates of 10-15%, even if low prices remain. Aside from increasing timber yields by improving management practices, providing farmers with more tree alternatives is imperative in order to improve the profitability of tree farming systems and to meet the needs of farmers, the industry and consumers. If good quality germplasm of a range of tree species is available, smallholder farmers are in a good position to achieve high tree yields due to the intensive and beneficial management (e.g., soil cultivation, weeding, fertilization) associated with intercropping trees in agroforestry systems. As with other tree products, smallholder upland farmers have demonstrated that they can produce large quantities of timber in their smallholdings and efficiently supply local, national and international markets. Although farm-grown timber currently holds only a modest market niche and is not a practical substitute for products requiring large diameter log, farm-grown timber is becoming increasingly

important in the timber industry and trade. The Philippine government and the wood industry sector should recognize the role of smallholder farmers as land managers and efficient producers of many important agricultural commodities, including timber.

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APPENDIX

1. Labor input (man-day ha^{-1}) for maize monocropping and maize-tree agroforestry systems over an 8-year tree rotation period

			Agroforestry systems					
	mz-monocrop		Hedg-cont cropping		Hedg-fallow		Block-fallow	
Activity	**md**	**mad**	**md**	**mad**	**md**	**mad**	**md**	**mad**
Layout hedgerows	3		3		3		7	
Maize cultivation wet season	607	229	270	102	193	63	128	41
Maize cultivation dry season	502	143	223	64	56	16	55	13
Tree establishment	0	0	42		42		83	
Tree management	0	0	19		24		51	
Total labor input per ha	1112	372	556	165	317	79	324	53

md: man-day

mad: man-animal-day