Journal of Environmental Science and Management SI-2: 76- 84 (2020) ISSN 0119-1144

The Economic Value of *Calliandra calothyrsus* in Watershed Rehabilitation in Manolo Fortich, Bukidnon, Philippines

ABSTRACT

This study analyzed the economic value of Calliandra calothyrsus Meissn. as a pioneer species in watershed rehabilitation using benefit-cost analysis (BCA). A cashflow was developed and using the 15% discount rate, the net present value (NPV) and benefit cost ratio (BCR) were computed. Planting C. calothyrsus as pioneer species is financially feasible having a positive NPV of PhP202,090 ha^{-1} and a BCR of 14 at 12 years rotation. Following the natural order of succession, benefits derived from planting pioneer species, in this case C. calothyrsus, include reduced labor cost for weeding while attaining benefits like fuelwood, honey and fodder production and environmental services like carbon sequestration. C. calothyrsus was used to shade out grasses and weeds, diminish fire hazard, and facilitate colonization of the site by a wider range of species through planting of desired premium species like dipterocarps to accelerate rehabilitation. Rehabilitation of degraded landscapes could accelerate forest succession using pioneer species to create favorable environment for late successional species, and ensure survival with positive contribution to ecosystem services.

Keywords: *Calliandra calothyrsus, net present value, benefit cost ratio, watershed rehabilitation*

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INTRODUCTION

Watersheds in the Philippines are vital life support systems that provide invaluable services like water supply for irrigation, biodiversity conservation, hydropower energy, and maintenance of river, lakes, wetlands and coastal ecosystems. However, many watersheds in the Philippines are suffering from excessive soil erosion, unpredictable streamflow patterns, diminishing groundwater reserves, loss of biodiversity, and declining land productivity, mainly due to increasing population (*Cruz 2012*), farm expansion and shifting cultivation (*GIZ and DENR 2013*) and poor vegetation cover dominated by *Imperata cylindrica* (cogon grass) (*Lee 2006*).

The main strategy of the government for improving watershed vegetation cover is through reforestation activities using fast-growing species, such as big leaf mahogany (*Swietenia macrophylla*), *Acacia mangium*, *A. auriculiformis*, *Eucalyptus deglupta* and *Gmelina arborea*. These species, however, are sensitive to drought, poor soils, and strong winds. Other reasons for low initial survival include fires, no maintenance, handling and transport damage, and farmer disturbance (*Chokkalingam et al. 2006*).

According to *Chokkalingam et al.* (*2006*), from late 1970s to 2000, US$570 million or more have been invested in forest rehabilitation in the Philippines. The total area reported as planted from 1975 to 2002 was 1,597,472 ha, with limited information on survival.

The Hineleban Foundation, Inc. (HFI), a non-government organization that advocates the re-establishment of rainforests in Mindanao mountain ranges starting in the forests of Bukidnon, initiated the planting of *Calliandra calothyrsus* Meissn., a fast growing tree, as a pioneer species to suppress fire-prone *Imperata cylindrica* L. grasslands in Manolo Fortich, Bukidnon. *C. calothyrsus* was observed successful in shading out grasses and weeds diminishing fire hazard and facilitating colonization of the site by a wider range of species through planting of desired premium species like dipterocarps, to accelerate rehabilitation. It was also observed that the nitrogen-fixing characteristic of *Calliandra* improved the fertility of the soil for the growth of premium species.

C. calothyrsus can best grow in areas with altitude from 250-1800 m, mean annual temperature of 22-28°C

and mean annual rainfall of 700-4000 mm and grows well on a wide range of soil types but does not tolerate waterlogged and alkaline soils (*Orwa et al. 2009*). The climate in the municipality of Manolo Fortich falls under Type III of the Modified Corona's Classification and is characterized as having a short dry season lasting only from one to three months and no pronounced maximum rain period. The area is virtually cloud-covered throughout the year. Temperature ranges from 22.7°C during January to 24.6°C in June. The area receives the highest amount of rainfall in June while March is the driest month. Relative humidity varies from 71% in May and 86% in September.

C. calothyrsus was observed to be efficient in shading weeds, specifically, *cogon* and *talahib* (*Saccharum spontaneum*) with no observed allelopathic effect to the planted late successional species, and improved the soil physical and chemical properties (*Macqueen et al. 2001*).

For better appreciation of the total benefits of using *C. calothyrsus* in improving the vegetation cover of watersheds in the country, there is a need to account and give value to the various ecosystem services provided by the addition of a pioneer species in watershed rehabilitation initiatives. The results of this process are also useful bases for comparing the benefits from using *C. calothyrsus* and other commonly used pioneer species for watershed rehabilitation. Therefore, this study analyzed the economic contribution of *C. calothyrsus* as a pioneer species in watershed rehabilitation. Specifically, the study sought to estimate the ecosystem services contributed by *C. calothyrsus* and calculate the economic contribution of using *C. calothyrsus* to the improvement of various ecosystem services.

MATERIALS AND METHODS

Activities for growing *C. calothyrsus*

The schedule of activities followed by the HFI in using *C. calothyrsus* as pioneer species were the sources of costs and benefits identified in the Benefit-Cost-Analysis (BCA) (**Table 1**).

The activities included were those performed prior, during and after plantation establishment. Activities conducted prior to plantation establishment include survey and mapping and pre-plant brushing and seedling propagation. Survey and mapping were initially done to evaluate the topography, slope and existing vegetation of an area and plan for subsequent activities like brushing, orientation and planting location. Once location and orientation were finalized, pre-plant brushing was done by clearing a 1-m length perpendicular to the slope orientation of the area and staking and hole digging followed.

Seeds were planted and grown to a height of at least 2 m before being uprooted as bareroot seedlings and transplanted in the field.

Plantation establishment include uprooting of seedlings, transporting bareroot planting materials to the field and transplanting in the field. Bareroot planting materials were subjected to practices like defoliation of 75% of the leaves and packing the roots with mud to slow down respiration of the seedlings. The use of taller seedlings was necessary to give the *C. calothyrsus* a head start over the grasses growing in the area.

Post plantation establishment include line brushing and was done in Years 2 and 3 to free the *C. calothyrsus*

Table 1. Schedule of activities for using Calliandra in watershed rehabilitation by Hineleban Foundation, Inc.

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Years 7 to 11	Year 12
Survey and Mapping	x								
Pre-plant brushing	x								
Clearing and hole digging	x								
Planting of seeds	x								
Uprooting of seedlings	x								
Transplanting of seedlings	x								
Line Brushing			x	x					
Trimming of branches			x	x		x	x	x	
Pruning of Calliandra			x	x		x	x	x	
Thinning of Calliandra					x				
Interplanting of premium species					x				
Green manure incorporation			x	x	x	x	x	x	x
Incorporation of bees		x	x	x	x	x	x	x	x

from vines that can strangle or impede their growth. Trimming of branches and pruning were done beginning Year 2 and will continue until Year 11. The herbage materials from trimming and pruning were left on the litter floor to serve as green manure. Thinning and interplanting of premium timber species were done in Year 4.

Valuation of uses

Benefits from *C. calothyrsus* include use values from fuelwood, fodder, green manure, honey production from the nectar of flowers and shading value. The value of fuelwood and honey production used were the prevailing market prices in the area.

Yearly trimming of branches and twigs yielded 5 tons ha-1, except in Year 4 when thinning was done and fuelwood yield was 20 tons ha^{-1}.

Honey collected from bees feeding on *C. calothyrsus* was estimated to be 75 L ha^{-1} for the five colonies in the study area, following honey yield obtained by *Crane et al.* (*1984*) of 1.3 kg $colony^{-1}$ $month^{-1}$. The honey yield is a conservative estimate compared with the honey harvested in Indonesia at 1 ton ha^{-1} (*Sila 1996*). In the case of Indonesia, *C. calothyrsus* was massively planted and a large number of colonies were reared that could forage in the abundant flowers, hence, the high yield of honey.

Fodder yield was assumed at 5 tons ha^{-1} fresh, a conservative assumption when compared with the results of *NAS* (*1983*) of 7 to 10 MT ha^{-1} of dry fodder having 22% crude protein. Green manure addition to the soil was reported at 54 kg N ha^{-1} provided by 3.9 tons of green manure (*Shelton et al. 1996*).

Carbon sequestration was computed only in Year 6 and Year 12. Only *C. calothyrsus* trees having a diameter-at-breast-height (dbh) of > 5 cm were included in the aboveground biomass computation, and computed using the formula:

Y = EXP (-2.134 + 2.53 ln D) (*Brown and Lugo 1990; Lasco et al. 2006*)

where: Y is the total above ground biomass (kg)
D is the dbh (cm)

The assumptions used for estimating the different use and non-use values of using *C. calothyrsus* for watershed rehabilitation include (**Table 2**):

Fuelwood. Selling price of fuelwood in the locality based from market survey was PhP 2.00 per bundle of about 2 kg weight or PhP 1 kg^{-1}.

Price ton^{-1} of fuelwood = 1,000 kg ton^{-1} x PhP 1 kg^{-1} = PhP 1,000 ton^{-1}

Honey. Price of honey in the market is PhP 250 L^{-1}.

Fodder. The price of fodder is based on the wage rate of PhP 300 d^{-1} prevailing in the locality. It is assumed that a person can collect 60 kg of *C. calothyrsus* fodder in one day.

$$\text{Price per kg of fodder} = \frac{PhP\ 300\ per\ day}{60\ kg\ fodder\ harvested\ per\ day}$$

$$= \text{PhP } 5.00\ kg^{-1}$$

Green manure. The price of green manure is based on the prevailing price of complete fertilizer, which was PhP 40.00 kg^{-1} having 14% of N. Addition of 54 kg N ha^{-1} was derived from 3.9 tons ha^{-1} green manure (*Shelton et al. 1996*).

$$\text{Price per kg of green manure} = \frac{PhP\ 40\ per\ kg\ of\ fertilizer}{0.14\ N}$$

$$= \text{PhP } 286.00\ kg^{-1}$$

Value of N added ha^{-1} = 54 kg x PhP 286 kg^{-1}

Cost avoided from weeding. The cost for weeding a hectare of land is used as the cost avoided when Calliandra was planted. It was estimated that as much as PhP 3,360 for Year 1 and PhP 1,680 $year^{-1}$ beginning Years 2 to 12 were saved from weeding.

Carbon sequestered. The prevailing market price for carbon sequestered is US$ 10 ton^{-1} of CO_2 (*Kiffner et al. 2015*).

Location and Duration of the Study

This study is part of a larger experiment commissioned by HFI to investigate the effectiveness of using *Calliandra calothyrsus* as a forest rehabilitation species in the re-greening of the slopes of Mt. Kitanglad range in the Province of Bukidnon. The study site is located at N 08° 12' 40.0", E 124° 52' 27.0" and N 08° 12' 51.5", E 124o 52' 33.7" (**Figure 1**).

Aside from the biophysical contributions of *C. calothyrsus* to watershed rehabilitation, BCA on the uses of *C. calothyrsus* was also estimated based on data collected from April to May 2014.

Table 2. Assumptions used for estimating the cost-benefit for 1 ha *Calliandra calothyrsus*.

Source of Benefits	Amount (PhP)	Source of Information
Fuelwood	PhP 1,000.00 per ton	Market survey during the conduct of the study
Honey	PhP 250.00 L^{-1}	Prevailing market price
Fodder	PhP 5.00 kg^{-1}	Based on prevailing wage rate in the locality
Green manure	PhP 286.00 kg^{-1} N	*Shelton et al.* (*1996*)
Cost avoided from weeding	Year 1 – PhP 3,360.00	HFI data
	Years 2 to 12 – PhP 1,680.00 yr^{-1}	HFI data
Carbon sequestered	PhP 500 per ton of CO_2 sequestered is valued at US$10 (1US$ = PhP 50.00)	*Kiffner et al.* (*2015*)

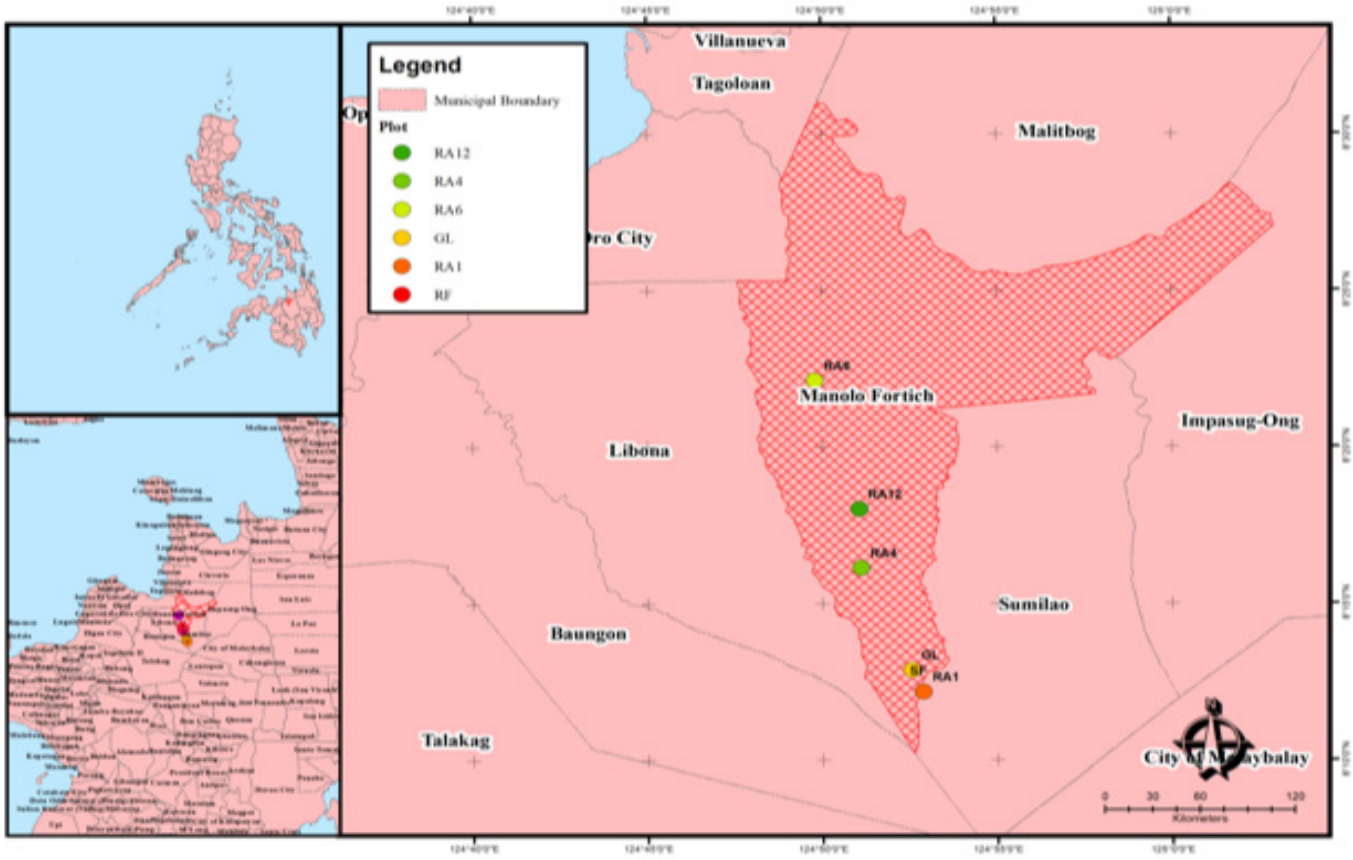

Figure 1. Location of the study site in investigating the effectiveness of using *Calliandra calothyrsus* as watershed rehabilitation species in Manolo Fortich, Bukidnon, Philippines.

RESULTS AND DISCUSSIONS

Cost and Benefits of *C. calothyrsus*

The costs and benefits of 1-ha of *C. calothyrsus* based on 2014 plantation establishment expenses per hectare of HFI in Bukidnon, Misamis Oriental include those that were incurred prior to plantation establishment like survey and mapping, pre-plant brushing, staking, hole digging, cost of planting materials and transportation or hauling costs (**Table 3**). The establishment cost of the *C. calothyrsus* plantation include trimming and pruning costs of branches and twigs both for fodder and green manure that were done every year beginning in Year 2.

Trimming and pruning costs were based on existing local wage rate of PhP 300 d^{-1}. The interplanting in Year 4 coincided also with the thinning done to the planted *C. calothyrsus* to give space for the planting of premium tree species. Protection costs were incorporated in the sources of costs.

C. calothyrsus' contribution to the Clean Development Mechanisms under the Kyoto Protocol through carbon sequestration was also incorporated. The *Calliandra* plantations used in the study were established in a previously agricultural land planted with corn, hence, Article 12, no. 5 of the Kyoto Protocol has been complied with.

Table 3. Economic valuation of *Calliandra calothyrsus* for watershed rehabilitation.

Items	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
Benefits													
Fuelwood		-	5,000	5,000	20,000	5,000	5,000	2,500	2,500	2,500	2,500	2,500	
Honey produced			18,750	18,750	18,750	18,750	18,750	9,375	9,375	9,375	9,375	9,375	
Fodder			25,000	25,000	25,000	25,000	25,000	12,500	12,500	12,500	12,500	12,500	
Green manure			15,444	15,444	15,444	15,444	15,444	7,722	7,722	7,722	7,722	7,722	
Cost avoided from weeding		3,360	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680	1,680
Carbon sequestration							5,875						400
Total Benefits	-	3,360	65,874	65,874	80,874	65,874	65,874	33,777	33,777	33,777	33,777	33,777	1,680
Costs													
Survey and Mapping	1,540												
Planting materials	4,400												
Pre-plant slashing	2,000												
Clearing and staking	1,110												
Hole digging and planting	1,110												
Trimming/ Pruning of branches			1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	
Thinning					2,800								
Protection		2,000	2,000	500	500	500	500	500	500	500	500	500	500
Total Costs	10,160	2,000	3,400	1,900	4,700	1,900	1,900	1,900	1,900	1,900	1,900	1,900	500
Net Benefit	(10,160)	1,360	62,474	63,974	76,174	63,974	63,974	31,877	31,877	31,877	31,877	31,877	1,180
NPV (15%)*	202,090												
BCR	14.41												

*Source: *NEDA* (*2016*)

Fuelwood production started in Year 2 but is highest in Year 4 when thinning of lines of *C. calothyrsus* is done to create space for the planting of premium species. Beginning Year 7, fuelwood will decrease because of the lesser biomass produced from *C. calothyrsus* as a result of the shading effect of the premium species. *Wiersum and Rika* (*1992*) reported annual wood yields from *C. calothyrsus* from 15-40 t ha^{-1} with annual coppice harvests continuing for 10-20 years. In Indonesia, *Duke* (*1983*) reported that *C. calothyrsus* can be cut a year after planting and annually for 15-20 years. In Uganda, however, wood production was observed to decrease after 8-10 years (*Mawanda 2004*).

Honey produced from foraging on the nectar from the *C. calothyrsus* flowers started in Year 2 and will continue until Year 12 but production will decrease in Year 7. In Year 7, *C. calothyrsus* will be shaded, decreasing flower production and consequently honey production.

In areas in Java, Indonesia with well-established *Calliandra* trees, 1.3 kg per colony per month of honey were harvested from hives containing the *Apis cerana* bee (*Crane et al. 1984*). In addition, the presence of hives may also increase pollination in adjacent agricultural crops (*Mawanda 2004*).

Fodder from the twigs, leaves and small branches is also another benefit source. Animals will benefit from the fodder because *C. calothyrsus* has 13.9% to 22.7% crude protein on a dry matter basis (*Jayaprakash 2016*) while *Macqueen et al.* (*2001*) reported that leaf material contains 17-28% crude protein (dry matter basis). Green manure is another benefit from *C. calothyrsus*. With the analysis of *C. calothyrsus* as having 3.10% nitrogen, 0.36% phosphorus and 0.20% potassium (*Kartasubrata 1996*), it is a good source of green manure for the interplanted plants. *C. calothyrsus* is fast growing even on poor soils, and has the ability to improve soil fertility, but it does not do well on acidic soils (*Franzel et al. 2004*). In Indonesia, *C. calothyrsus* has been planted in fallow or in mixture with crops, for the supply of green manure (*Verhoef 1941*). An increase of 52% in grain yield when *C. calothyrsus* was used as green manure has been reported in Cameroon (*Tonye et al. 1994*).

The nurse crop/pioneer tree function of *C. calothyrsus*has been valued using the cost avoided from weeding. With planting of *C. calothyrsus*, it is no longer necessary to conduct yearly weeding. The shading effect of *C. calothyrsus* is enough to suppress cogon (*Imperata cylindrica*) and talahib (*Saccharum spontaneum*).

Carbon sequestration is another benefit derived from *C. calothyrsus*. The biomass stored in the *C. calothyrsus* stand was determined using the diameter at breast height measurement.

The highest expenses for the establishment of a *C. calothyrsus* plantation by the HFI was incurred in Year 0, which also corresponded with the pre-plantation and plantation establishment. Year 0 expenses for establishing one ha *C. calothyrsus* amounted to PhP10,160.00 with 15% of the amount for survey and mapping, 43% for planting materials and the remaining 42% for pre-plant slashing, clearing, staking and hole digging.

Protection activities conducted by HFI for *C. calothyrsus* were undertaken beginning Year 1 until Year 12 with annual costs of PhP 2,000.00. The thinning activities done in Year 4 incurred a cost of PhP 2,800.00 ha^{-1}. Yearly trimming of branches for fodder and fuel is being proposed and will cost PhP1,400.00 yr^{-1} from Years 2 to 11.

Highest benefits occurred in Year 4 when thinning of *C. calothyrsus* was done to prepare the area for planting of premium species. Beginning Year 2, benefits from fuelwood, honey produced, fodder, green manure, cost avoided from weeding had been realized. Carbon sequestration was valued in Year 6 and Year 12. Beginning Year 2 up to Year 6, total benefits were PhP 65,874.00 for all years, except in Year 4 when total benefits amounted to PhP 80,874.00. Beginning Year 7, total benefits decreased to PhP 33,777.00 and were lowest in Year 12 at PhP 1,680.00. The decrease in benefits derived from the *C. calothyrsus* plantation also coincided with the diminishing biomass of *C. calothyrsus* due to shading of big premium species. High cost and high benefit occurred in Year 4 coinciding with the thinning activity to prepare the area for planting of intended premium tree species.

A lower NPV compared with the rainforestation farming strategy (afforestation with indigenous tree species, intercrops and fruit trees) done by *Kiffner* (*2015*). The NPV realized using the Rainforestation Farming Strategy was PhP 661,558.00 at 12.2% discount rate. On the other hand, the result of *Predo et al.* (*1998*) for the NPV of napier grass strip system and annual maize-maize between hedgerows was lower at PhP 11,095.00 when compared with the results of this study.

Successful plantation establishment in grasslands requires an intensive operation that will achieve fast early canopy closure of trees that will suppress the growth of obnoxious weeds. Plantation forestry establishment in *Imperata cylindrica* (L.) grasslands in Indonesia is technically feasible and financially profitable, provided that fast early growth and high yield per hectare are achieved (*Kuusipalo et al. 1996*). Fast early growth and canopy closure ensure rapid suppression of the grass, thereby reducing competition and fire susceptibility. Elements of a successful reforestation system in Imperata areas are species and provenance selection, production of viable seedlings, site preparation and amelioration, adequate spacing, a proper layout and management plan for the plantation, and an effective fire prevention and fire-fighting system.

The study by *Kuusipalo et al.* (*1996*) reported that plantation trees in Indonesia can be harvested at the age of 6-15 years. With a stumpage price of US$ 20 m^{-3}, a mean annual increment of 25 m^3 ha^{-1} is sufficient incentive for the entrepreneur.

In the study of *Harrison et al.* (*2005*) in Leyte Province, Philippines, showed that based on a mean annual increment of 20 m^3 yr^{-1}, the stumpage prices of PhP 2,600.00 m^{-3}, and real discount rate of 15%, the NPV for mangium is PhP 12,641 ha^{-1}.

The study by *Niskanen and Saastamoinen* (*1996*) showed that reforestation was estimated to be financially more profitable in Northeast Thailand than in Luzon, the Philippines. Comparisons were made only for gently sloping sites in the Philippines, since the results were not assessed on moderately or steeply sloping sites in Northeast Thailand where the terrain is normally flat. Teak (*Tectona grandis* L.f.) plantations in Thailand with a 25-year rotation period were most profitable from the point of view of the private investor, although some uncertainties related to the growth and yield assumptions remained. The high profitability of Teak plantations was primarily based on the capability of parquet and furniture manufacturing industries to pay high stumpage prices for timber. Eucalyptus plantations in Thailand were also more profitable than acacia or mahogany plantations in the Philippines, although in the latter, Acacia plantations were financially more profitable to grow than mahogany plantations. In the future, the order of profitability between these species in the Philippines may change if more rational utilization of mahogany timber by the wood processing industries occurs, thus raising its price. As an example, the net present value of the industrial reforestation investment in the Philippines was PhP 8,769.00 and PhP 3,161.00 ha^{-1} for acacia and mahogany, respectively. While an economic analysis of reforestation with a native tree species conducted in Vietnam by *Nguyen et al*. (*2014*) shows that reforestation with *Canarium album* (native

tree species) is less financially profitable than that with an exotic tree species (*Acacia mangium*). However, NPV at 5% discount rate in 2012 and both labor wages and timber prices were unchanged showed that VND 42,639,000 ha^{-1} (USD 1,835.00 ha^{-1}) and VND 51,252,000 ha^{-1} (USD 2,206.00 ha^{-1}) was realized for *A. mangium* (exotic) and *C. album* (native), respectively. The reason for higher NPV with native species is the higher timber volume per hectare and price, however, rotation with *C. album* is longer. In a study on oil palm cultivation in Indonesia showed that an 8,000-ha plantation over 25 years resulted in a positive NPV of US$ 10,670.00 (*Svatonova et al. 2015*). The high returns to oil palm plantation has caused conversion of forest lands in other parts of Indonesia like Central Kalimantan (*Muratni et al. 2016*) and grown even in peatlands (*Agustira and Ranola 2017*). Other species like African mahogany plantations in Brazil were studied to show that trees are a great forest investment opportunity (*Ribeiro et al. 2018*). In China, poplar (*Populus* sp.) plantations were analyzed to have an NPV of USD 1,024.00 to USD 6,295.00 ha^{-1} (*Wang et al. 2014*).

The economic analysis conducted by *Nijnik et al.* (*2013*) concluded that choosing appropriate tree species and locations for tree planting are important considerations. Afforestation with relatively fast-growing tree species (e.g., Sitka spruce (*Picea sitchensis* (Bong. Carr.) on low grade agricultural land maybe a cost-effective option.

A partial budget analysis was conducted for *C. calothyrsus* as a supplement to farmers' basal feed and as a substitute for dairy meal in 2001 showed an NPV of US$ 260.00 at 20% discount rate (*Franzel et al. 2004*). The study of *Mucheru-Muna et al.* (*2007*) on planting *C. calothyrsus* alone showed that net benefit, BCR and return to labor were US$ 747.3, 4.4 and 9.0, respectively.

Using valuation to determine the contribution of *C. calothyrsus* in watershed rehabilitation showed that at 15% discount rate, a positive NPV and a BCR >1 for 12 years growing period has been realized. Investing in planting pioneer species to colonize an area provides provisioning, regulating and supporting services. Provisioning services are in the form of fodder, fuelwood, green manure and nectar for honey production. Provisioning services include carbon sequestration measurements in this study while supporting services include nutrient cycling, infiltration and stability, and were evaluated using Landscape Function Analysis LFA, a procedure for looking at habitat quality and its changes over time.

CONCLUSIONS AND RECOMMENDATIONS

The Cost Benefit Analysis (CBA) for *C. calothyrsus*, when used in watershed rehabilitation using a 15% discount rate, resulted in a positive NPV of PhP 202,090.00 and a Benefit-Cost Ratio (BCR) of 14, showing that it is beneficial to use *C. calothyrsus* as a pioneer species in watershed rehabilitation.

For a successful watershed rehabilitation, the natural succession can be accelerated by planting pioneer species like *C. calothyrsus*. These pioneer species improves the soil properties for the future planting of late successional species by increasing organic matter, moisture and shade, contributing to higher survival rate and ultimately to successful rehabilitation, devoid of unsuccessful repetitive planting.

There is the need to conduct capacity-building of personnel to implement rehabilitation efforts (whether private or public initiated) on accelerating ecological succession and valuing use and non-use values of the rehabilitation; develop a favorable environment for late successional species or desired trees that mimics the forest succession; implement the appropriate silvicultural treatments for pioneer species or *C. calothyrsus* to maximize benefits derived from the tree and perform appropriate silvicultural treatments to enable maximum benefits from the pioneer species.

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ACKNOWLEDGMENT

The Hineleban Foundation, Inc. in Manolo Fortich, Bukidnon through Mr. John Perrine and Mr. Neil Konrad Binayao III for the overall support during the conduct of the study.