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Technical and financial feasibility of almaciga plantation development in Governor Generoso, Davao Oriental, Philippines

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ABSTRACT. Almaciga (*Agathis philippinensis* Warb.) is a tree species indigenous to the Philippines that produces Manila copal, a resin used to manufacture paints and varnishes. It is classified as vulnerable by the International Union for Conservation of Nature (IUCN) and the Department of Environment and Natural Resources (DENR) through DENR Administrative Order No. 2017–11 (DENR 2017). Almaciga resin tapping is an important means of livelihood for some indigenous peoples. It is currently sourced from natural forests and developing plantations can improve its conservation status by lessening the resin extraction intensity from natural stands and at the same time help meet the increasing demand. This paper evaluates the financial and technical feasibility of developing almaciga plantations in Governor Generoso, Davao Oriental, Philippines. Using primary and secondary data, the technical aspect was evaluated based on land suitability and the availability of plantation development technology, while the financial feasibility considered the costs and revenues of developing almaciga plantations. Sensitivity analysis was also conducted. The suitability map shows about 3,768 ha suitable for almaciga plantation in the area. At a 10% discount rate, the NPV is PhP 160,233.40 ha^{-1} and the BCR is 4.75, while the IRR is 19%, indicating that the plantation is financially profitable. The sensitivity analysis revealed that the financial viability of almaciga plantation is more sensitive to a resin price decrease than to an increase in establishment cost. This plantation may be less appealing to the private sector as tapping can begin when the trees are about 21 years old. Thus, the study recommends that the government lead the development of almaciga plantations as a reforestation or plantation species in areas where it is suitable.

Keywords: *Agathis philippinensis, Manila copal, resin, site-species suitability*

INTRODUCTION

As of 2010, the forest cover of the Philippines was estimated at 6.84 M ha, or about 23% of the country's total land area of 30 M ha (Forest Management Bureau 2018), down from 90% before the Spanish colonization 400 years ago (Carandang & Lasco 1997), 70% in the 1900s, and 37% in the 1980s (Liu *et al*. 1993). The drastic decrease in forest cover, especially after World War II until the early 1980s, was attributed to the excessive harvesting of logs from the forests for export and domestic uses. Forest degradation remains a major problem in the Philippines, adversely affecting the production of wood and non-wood forest products.

To address this, the government issued Executive Order No. 23, which among other things, declared a ban on the harvesting and cutting of timber in natural and residual forests in the country. Forest rehabilitation efforts, such as the National Greening Program (NGP), have also been pursued to alleviate the situation of the Philippine forests. The ban of logging in natural and residual forests shifted the source of lumber and other wood products to plantations. Plantation forestry comes with relatively high inputs and intensive monoculture management to produce a rather range of products (Kanowski 1995 as cited in FAO 1997). However, when the demand for non-wood products and services is strong, a broader range of plantation objectives and a more intimate integration with other land uses are necessary for successful plantation production. This highlights the need to redefine plantation forestry to promote an understanding of its potentially broader role (Evans 1992).

In the Philippines, tree farming has been accepted as an alternative to traditional agriculture. There is now more than 100,000 ha of tree plantations in the Caraga Region and other provinces in Mindanao. Plantations are financially attractive, produce much-needed wood for industry, and create many jobs (FAO-UN 2012). Most of the plantations established in the Philippines used exotic and fast-growing species, focusing on the production of wood, which is usually considered the most valuable material that can be derived from a tree. Indigenous species are seldom used due to their long rotation periods.

Aside from wood, other important forest products that can be derived from the forest are non-timber forest products (NTFP), which refer to all biological materials other than timber extracted from the forest for human use (Shackleton *et al*. 2011). One of the valuable NTFPs in the Philippines is almaciga resin or Manila copal derived by tapping almaciga trees. The only sources of almaciga resin in the Philippines at present are natural stands. Almaciga has been classified as vulnerable by the International Union for Conservation of Nature (IUCN). Developing almaciga plantations for resin production can help ease the pressure on natural almaciga stands.

Species with long rotations like almaciga are not commonly used for forest plantations. One of the objectives of establishing a forest plantation is to produce wood and other products for industrial purposes. Establishing a forest plantation may mean large costs, and the long rotation period implies a long payback period, and the investment is prone to risks and uncertainties. Aside from investments, the site-species suitability must be considered in plantation development to ensure that the desired species will thrive in the selected site. Climatic, edaphic, anthropogenic, physiographic, and geographic are factors that affect site-species suitability. Intensive labor is needed and other inputs, such as land and planting stocks, are also important. Knowledge of forest plantation development is likewise necessary to perform needed tasks and activities. However, before developing a tree plantation, its financial feasibility should first be assessed. This will determine the financial limits in planning activities and explore possible profitability. It will also be a basis for decision-making whether or not to develop a forest plantation. Sensitivity analysis may be conducted to predict future situations in cases of uncertainty.

The study was conducted under Calderon *et al*.'s (2021) project on the "Market Assessment and Financial Feasibility of the Production of Chemical Non-Timber Forest Products." The project extensively studied the market for almaciga resin and found, among other things, that the buyer of almaciga resin from Governor Generoso is interested in buying more resin than what the tappers can supply and imports resin from Indonesia. They also found that the demand for almaciga resin for domestic use and export was high at the national level.

This paper evaluated the financial and technical feasibility[1] of developing almaciga plantations in Governor Generoso, Davao Oriental, Philippines. Specifically, it developed a site suitability map for almaciga plantation development, assessed the profitability of almaciga plantation development, and analyzed the sensitivity of the profitability of almaciga plantation to various factors.

METHODOLOGY

Study site

The study was conducted in a part of the Mt. Hamiguitan Range Wildlife Sanctuary under the coastal municipality of Governor Generoso, Davao Oriental. The municipal center of Governor Generoso is situated at approximately 6° 40' north and 126° 5' east on the island of Mindanao. Elevation at these coordinates is estimated at 17.0 m asl. It has a land area of 36,575 ha with 20 barangays, of which 10 are involved in almaciga resin harvesting (**Figure 1**). These barangays are Sergio Osmeña, Tandang Sora, Upper Tibanban, Oregon, Tiblawan, Luzon, Surop, Tagabebe, Pundaguitan, and Tamban (Modeno 2019).

Data collection

The study used primary and secondary data. Primary data on plantation development, resin tapping practices, and the income derived from resin tapping were gathered through a survey of resin tappers and key informant interviews. Secondary data on almaciga plantation development activities and costs, yield, and other information were obtained from publications and online sources. The raster and vector image files used for site-species suitability map generation were derived from online sources, while the cost of plantation development used by the government was obtained from the Forest Management Bureau Technical Bulletin No. 10-A (FMB TB 10-A) (FMB 2018 & 2021) or the Updated Standard Seedling Cost and Unit Cost of Activities of the NGP. These provided the basis for the cost estimates of forest plantation development. It enumerated the different NGP activities, corresponding costs, and seedlings cost by commodity to have a standard, orderly, and effective program implementation. It is used by the stakeholders involved in planning, implementing, and managing forest resources and forest lands, such as personnel of DENR, LGUs, and forest communities.

[1] *The study did not include the market feasibility assessment because this was covered by the project of Calderon et al. (2021) under which this study was conducted.*

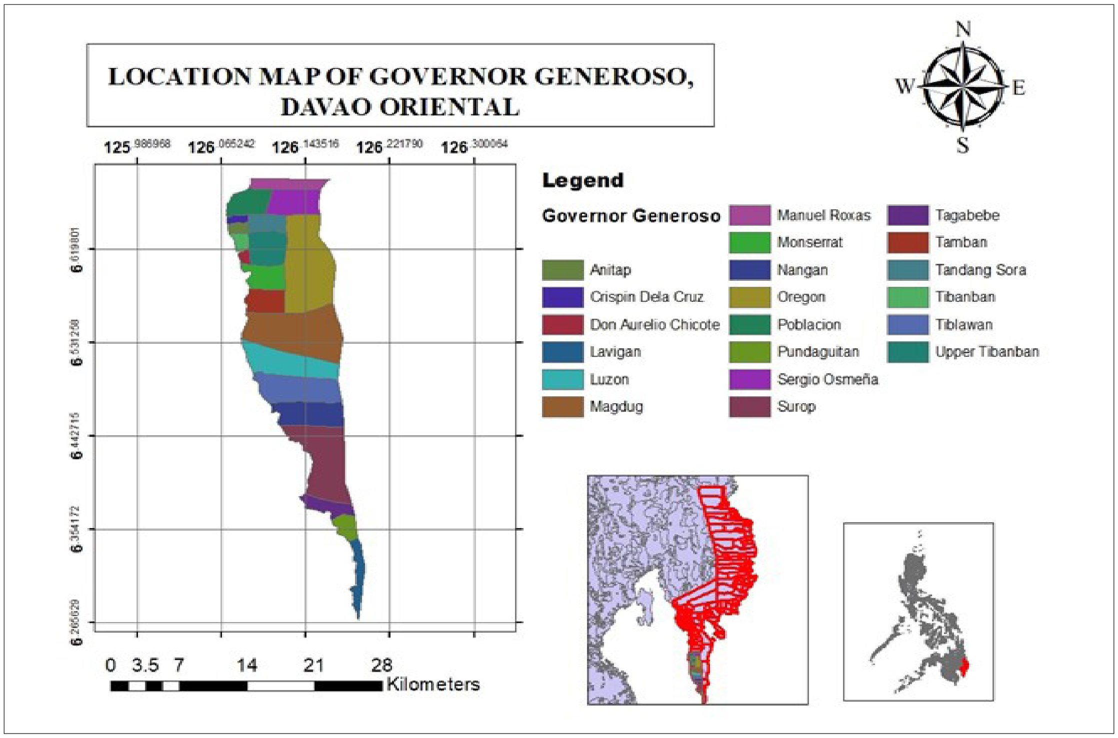

Figure 1. Location map of Governor Generoso, Davao Oriental, Philippines.

Site-species suitability map

A site-species suitability map for almaciga was developed to identify areas in the study site suitable for the growth of almaciga trees. A geographic information system (GIS) was used to store, process, and analyze the data for suitability analysis. Thematic maps were used to develop a suitability map for almaciga plantations. The 2015 landcover map of Davao Oriental was sourced from the National Mapping and Resource Information Authority (NAMRIA) and had a coordinate system based on Philippine Reference System 1992 (PRS92). Thematic maps and attribute data were downloaded from philgis.org, which uses a coordinate system based on the World Geodetic System of 1984 (WGS 84). These attribute data were processed using the WGS 84 coordinate system.

Thematic maps of site factors (soil characteristics, climatic factors, physiographic factors, and biotic) were converted to raster format map layers, reclassified into distinct classes that were later used to assess the site suitability almaciga (**Figure 2**). Each of the classes was assigned a score ranging from 0–5 to determine the suitability level of each class for almaciga plantation (**Table 1**). The scoring of each class of the attributes was based on secondary data gathered regarding the suitable conditions for the growth of almaciga tree. Attributes with a score of 0 meant that they were not suitable at all for almaciga plantation development. Attributes with a score of 0 were the least suitable attribute, while a score of 5 indicated that the area was very suitable for almaciga plantation.

Almaciga does not require a specific slope class to grow. However, according to the Comprehensive Land Use Plan or CLUP Guidebook (Housing and Land Use Regulatory Board 2014), the ideal slope for tree plantations should be 50% and below, thus the slope class of 30–50% was given a score of 5. The remaining slope classes were scored depending on suitability to tree plantations.

Among the 11 identified land cover types in the study site, cropland, cultivated areas, mangrove vegetation, and arable lands were given a score of 0 because the survival of almaciga trees in these areas land cover types would be impossible. Open-canopy forests, coconut plantations, and closed-canopy forests were scored with 5, 4, and 3, respectively, because these land cover types satisfy the requirement for the survival of almaciga trees during early years when they require shade from other vegetation. The soil type was scored based on its suitability for almaciga growing. The two identified soil types on the study site, Malalag loam and San Miguel silty clay loam, are suitable for the growth of trees (Carating *et al*. 2014). Almaciga thrives in areas with elevation ranging from 250–2,200 m asl (Boer & Ella 2000). This range of elevation was scored with 5, while above and below this elevation was scored with 0. Precipitation and temperature in the study site were inside the range required for almaciga growth based on ERDB (2013); thus, a score of 5.

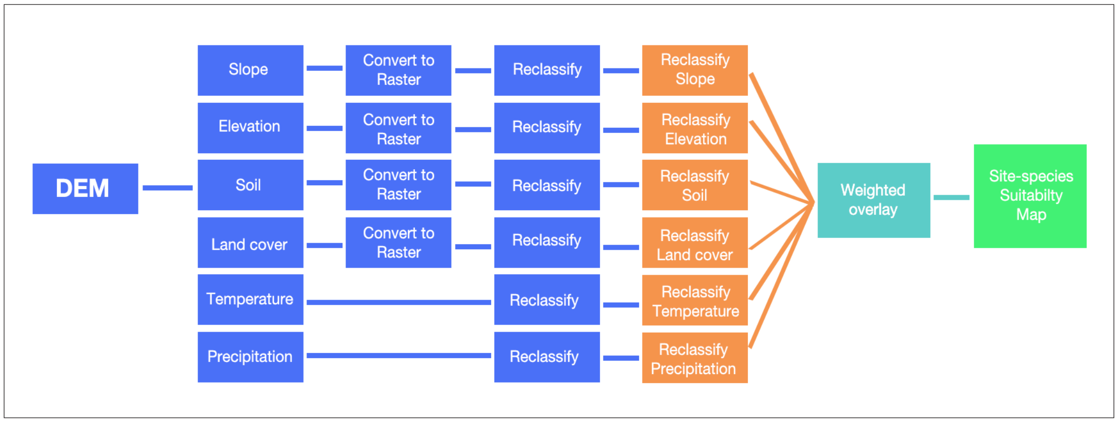

Figure 2. Mapping model used to produce a site-species suitability map for almaciga.

Table 1. Site factors of Governor Generoso, Davao Oriental and their corresponding classes and score.

Site factor	Classes	Score
Slope	0 – 8%	2
	8 – 18%	3
	18 – 30%	4
	30 – 50%	5
	50% above	1
	Cropland mixed with coconut plantation	0
	Cultivated area mixed with brushland/grassland	0
	Coconut plantations	4
	Mangrove vegetation	0
	Open canopy, mature trees covering <50%	5
	Closed canopy, mature trees, covering >50%	3
	Arable land, mainly cereals and sugar	0
Soil	San Manuel silty clay loam	5
	Malalag Loam	5
Elevation	250 m asl below	0
	250–2,200 m asl	5
	2,200 m asl above	0
Precipitation	2,500–5,000 mm yr^{-1}	5
	2,500 mm yr^{-1} below	0
	5,000 mm yr^{-1} above	0
Temperature	22°C–32°C	5

The different site factor layers were overlayed to produce the final output map. Each of the site factors was given an equal influence percentage. The model used in the study has resulted in a stretched suitability map with values from 0–5.

The values in **Table 2** define the level of suitability of the area for almaciga plantation.

Table 2. Suitability value with its corresponding level of suitability.

Value	Level of suitability
0	Not suitable
4	Moderately Suitable
5	Most suitable

Financial feasibility analysis

A financial feasibility analysis was conducted to assess if almaciga plantation development for resin production is a feasible option. It also tells if the project is worth investing in by the government or the private sector. The data gathered were organized and processed to compute the profitability indicators of almaciga plantation from resin tapping. The cash flow was constructed using the values of costs and revenues discussed earlier, assuming constant prices. The discount rate used in this study is 10%, based on the social discount rate (SDR) recommended by the National Economic and Development Authority (Investment Coordination Committee 2016).

The costs that arise from activities for plantation development are site preparation and planting in year 0 and maintenance during the first three years of the plantation to ensure the survival of almaciga seedlings. In the first year, weeding and brushing are done four times a year and replanting to replace seedlings that did not survive. Maintenance needs to be conducted for the second and third years of the plantation but with a reduced frequency of three times a year. The resin harvesting cost beginning year 22 was computed by dividing the total annual harvesting cost gathered from the survey by the total annual resin yield.

For the revenue side, the factors considered were resin volume and price. According to Ella (2018), a productive almaciga tree can produce 15–20 kg of resin annually. The price of almaciga resin per kg used was the pick-up price of the resin in the study site, which corresponds to the farmgate price.

The growth increment of almaciga tree based on diameter was assumed to be 2 cm yr^{-1} based on a key informant's observed growth rate of about 1.8 cm yr^{-1} and the report of Ella (2018) that the annual diameter increment of almaciga can easily exceed 1 cm. Based on this, resin tapping can start in year 21, but the resin yield in the first year of tapping will be very low (Ella 2000); thus, this was not included in the benefit stream. In the Philippines and other countries like Indonesia and Papua New Guinea, the maximum resin productivity of almaciga trees was around 15-20 kg yr^{-1} $tree^{-1}$ (Ella 2018). The resin tappers observed that the resin yield increases as almaciga trees mature. In the absence of resin yield studies, the productivity curve of almaciga resin was assumed to follow the sigmoidal curve model where the volume of resin yield will reach its peak and be constant throughout the productive life span almaciga tree. Hence, in year 22, the resin yield was assumed to be 15 kg $tree^{-1}$ yr^{-1}, will increase at a rate of 1 kg $tree^{-1}$ yr^{-1} until year 26, will reach its peak production of 20 kg $tree^{-1}$ yr^{-1} in year 27, and will be constant throughout the productive lifespan of the tree. Almaciga trees continue to produce resin throughout their lifespan, several hundreds of years (Ella 2018). For this study, however, a rotation of 100 years was used.

To evaluate financial feasibility, the net present value (NPV), benefit-cost ratio (BCR), and internal rate of return (IRR) were determined. The NPV is obtained by subtracting the present value of the cost stream from the present value of the benefit stream of a project, the BCR is the ratio of the present value of the benefit stream to the present value of the cost stream of a project, while the IRR is the discount rate that makes NPV equal to zero (Gittinger 1982). The NPV, BCR, and IRR were obtained using Equations 1, 2, and 3, respectively:

Equation 1:

$$NPV = \sum_{t=0}^{T} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{T} \frac{C_t}{(1+r)^t}$$

Equation 2:

$$BCR = \frac{\sum_{t=0}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{T} \frac{C_t}{(1+r)^t}}$$

Equation 3:

$$0 = NPV = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+IRR)^t}$$

where: B_t = Benefit in Year t; C_t = Cost in Year t; r = Discount rate; t = any year within the rotation; and T = rotation.

Based on the indicators derived, the almaciga plantation was evaluated to be feasible if NPV is positive, BCR is greater than 1, and IRR is greater than the discount rate. Conversely, the project is not feasible if NPV is negative, BCR is less than 1, and IRR is less than the discount rate.

Sensitivity analysis

Sensitivity analysis was conducted to identify factors that could affect the profitability of the plantation. The factors were the unit price of the Manila copal, plantation establishment cost, and discount rate. This analysis aimed to determine how each factor affects the revenue when other factors are held constant (Fuess & Zaiat 2018). The factors were subjected to three levels of variation: 10%, 30%, and 50% decrease in the market price of Manila copal, 10%, 30%, and 50% increase in the establishment cost, and alternative discount rates of 11%, 13%, and 15%.

RESULTS AND DISCUSSION

The site requirements of almaciga were used as bases in developing the suitability map for the almaciga plantation. For the land cover, the most desirable feature is the area with vegetation that can provide shade during the early development of the seedlings, provided there is enough sunlight to sustain its minimum requirement (ERDB 2013). Furthermore, almaciga can thrive in areas with an altitude of 150–2,200 m asl. The mean annual temperature should be 22–32ºC and mean annual rainfall of 2,500–5,000 mm yr^{-1}. The soil type must be light, medium-heavy, free-draining, and acidic (Orwa *et al*. 2009). The slope of the area for plantation development, as recommended by the CLUP Guidebook (Housing and Land Use Regulatory Board 2014; BSWM 2017), should be within the range of $\leq$ 50% slope.

Land cover

There are 11 distinctly identified land covers in the study site: annual crop, brush/shrubs, built-up, closed forest, open forest, fishpond, grassland, inland water, mangrove forest, open/barren land, and perennial crop (**Figure 3a**). The brush/shrub and perennial crops are the most dominant among the different land covers in the study site, while mangrove vegetation has the smallest area. According to the Almaciga Manual prepared by the Centre for Sustainability PH Inc. and Forest Foundation Philippines (2017), almaciga seedlings should be planted in areas with existing vegetation to provide shade. Given the existing land cover, closed-canopy forest, open-canopy forest, and areas with perennial crops were considered as possible areas for almaciga plantations.

Slope

Five slope classes were identified: 0–3%, 8–18%, 18–30%, 30–50%, and above 50% (**Figure 3b**). The Housing and Land Use Regulatory Board (2014) recommends that production forests be established in areas with a slope of 50% below, and 53.6% of the study site falls under this slope class. Areas with an 18–30% slope can also be sites for plantations but are not as recommended as the 30–50% slope since it covers only a small portion of the study site.

Soil

The study site has two soil types distinctly identified: Malalag loam and San Manuel silty clay loam (**Figure 3c**). Malalag loam is an upland soil suitable for upland rice, corn, plantation crops, and perennial trees (Carating *et al*. 2014). On the other hand, San Manuel silty clay loam is a lowland soil, described as a well-drained soil with moderate to a high level of fertility. This is suitable for major land uses such as lowland rice, upland rice, corn, coconut, vegetables, sugarcane, root crops, and perennial trees. Malalag loam is the dominant soil series in the study site, while only 7.56% of the study site area falls under San Manuel silty clay loam. In reference to the elevation map (**Figure 3d**), areas with San Manuel silty clay loam soil are found in lower elevation while areas with Malalag loam are found in high elevation.

Elevation

The study site has an elevation ranging from 0–887 m asl (**Figure 3d**). Almaciga requires an elevation of 150–2,200 m asl (Orwa *et al*. 2009). Elevation above 150 m asl is concentrated in the eastern side of the study area where part of Mt. Hamiguitan is located. This explains the location of the forested area in the land cover map and the higher slope classes at the eastern side of the slope map.

Precipitation and temperature

The mean annual precipitation in the study site is nearly uniform (**Figure 3e**). The majority of the area of Governor Generoso has an average of 216–354 mm of rain every month or 2,592–4,248 mm of rain annually. The temperature map of Governor Generoso shows that the temperature ranges from 23ºC–27.3ºC (**Figure 3f**). The precipitation and temperature values in Governor Generoso are within the ranges of almaciga, which are 2,500–5,000 mm of mean annual precipitation and 22ºC–32ºC of mean temperature (Orwa *et al*. 2009). This was also based on the generated maps shown in **Figure 3f**.

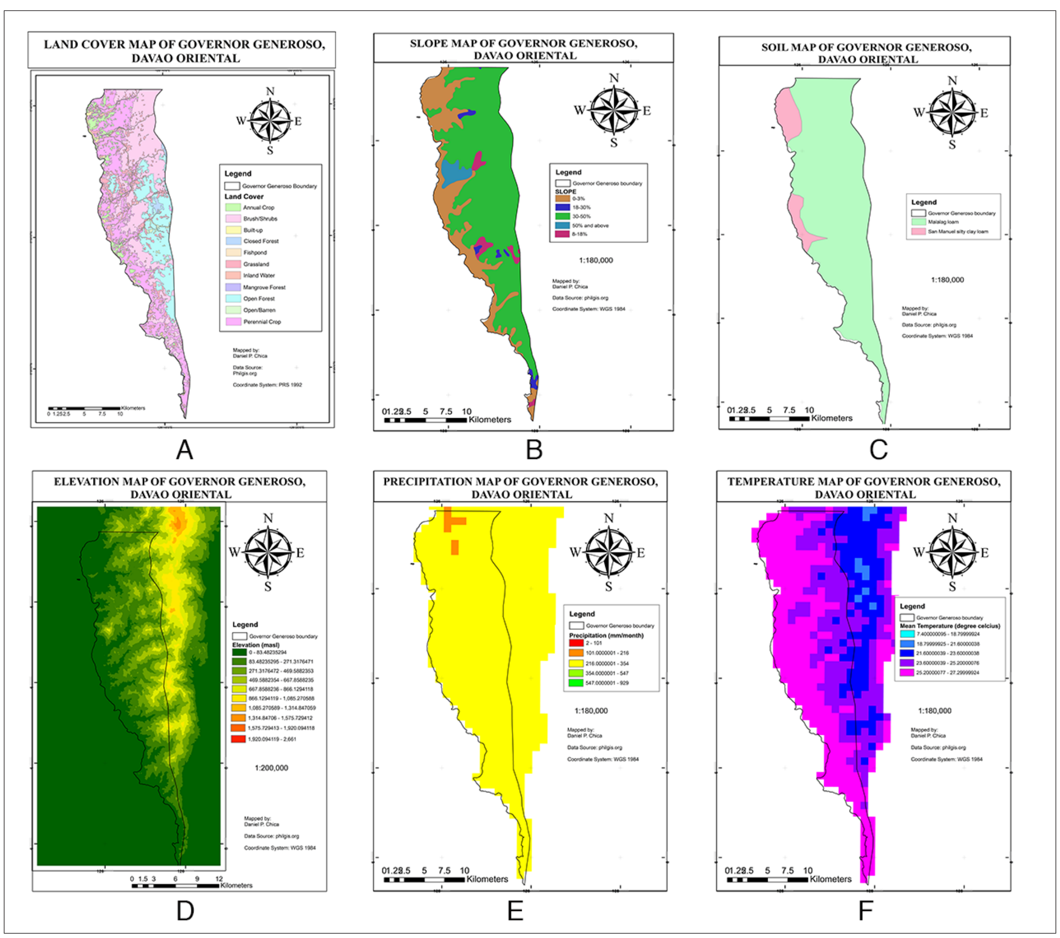

Figure 3. Thematic maps used to generate the site suitability map for almaciga plantation development in Governor Generoso, Davao Oriental, Philippines.

Site-species suitability map

The final site-species suitability map identifies areas of the study site with different levels of suitability for almaciga plantation (**Figure 4**). The green areas indicate the interest of this study on the map, which are the most suitable sites for almaciga plantation development. These areas satisfy the different site conditions favorable for almaciga growth. (Dolos *et al*. 2015) note that strong growth is also interpreted as high site suitability because it is also an indicator for tree vigor and site productivity. There are 145 patches of areas most suitable for almaciga plantation development with 4,525.80 ha. Some patches have areas less than 0.5 ha that may not qualify them for the definition of the forest by FAO (The Global Forest Resources Assessment) (FRA 2000) *i.e.* that forests should have a minimum area of 0.5 ha. These small patches reduced the number of patches suitable for almaciga plantation to 88, with 4,507.82 ha.

The total area suitable for almaciga plantation development is quite large and can help revive the population of almaciga trees for resin production in the future. Based on the GIS analysis, only a very small area (less than a hectare) suitable for plantation development can be found within the Mt. Hamiguitan Range Wildlife Sanctuary and was excluded in the financial analysis. The areas for almaciga plantation need not be cleared of existing vegetation and other tree species, but a significantly large number of almaciga trees will be added to the existing natural stands. This may have negative and positive effects on the biodiversity of the area. When the almaciga trees mature, the forest stand will resemble a mixed-species forest plantation and can reduce the biodiversity index of the forest in the area. Mixed species plantations may negatively affect biodiversity, *e.g.* the rainforest species used in plantations may invade remnant forests when planted outside their natural range. Also, there is a potential for genetic introgression into local populations if non-local provenances are used in plantations Kanowski *et al*. 2005).

The most suitable sites for almaciga plantation in Governor Generoso are distributed in six barangays: Oregon, Surop, Luzon, Tiblawan, Magdug, and Nangan (**Figure 5**). Among these barangays, Magdug and Nangan are not currently involved in almaciga resin harvesting.

Financial feasibility assessment

Plantation development costs and revenues

The costs incurred and the silvicultural practices in almaciga plantation development are summarized in **Table 3**. The costs for almaciga plantation development are mainly for labor and seedlings. The daily wage rate for labor based on the FMB TB 10-A is PhP 370.00 day^{-1}, while the price of almaciga seedling was based on the pickup price of almaciga seedlings in Governor Generoso. The initial activity in plantation development is site preparation, which involves brushing and

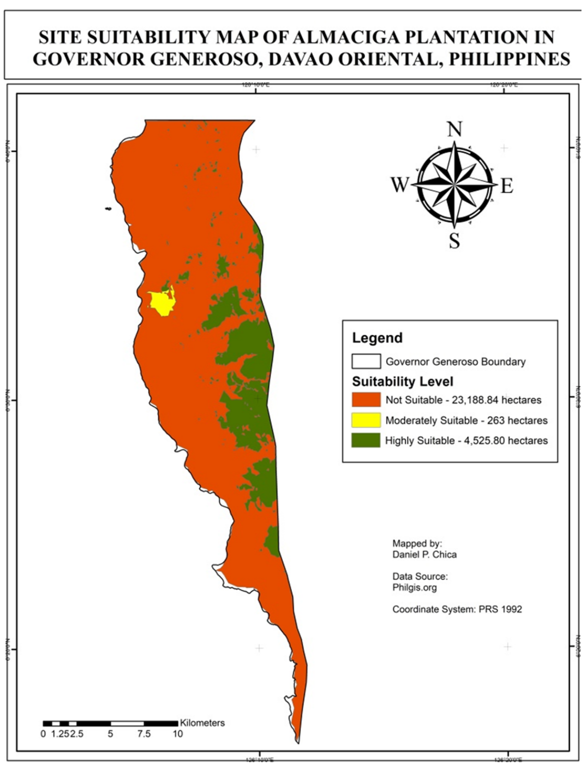

Figure 4. Site suitability map for almaciga plantation in Governor Generoso, Davao Oriental, Philippines.

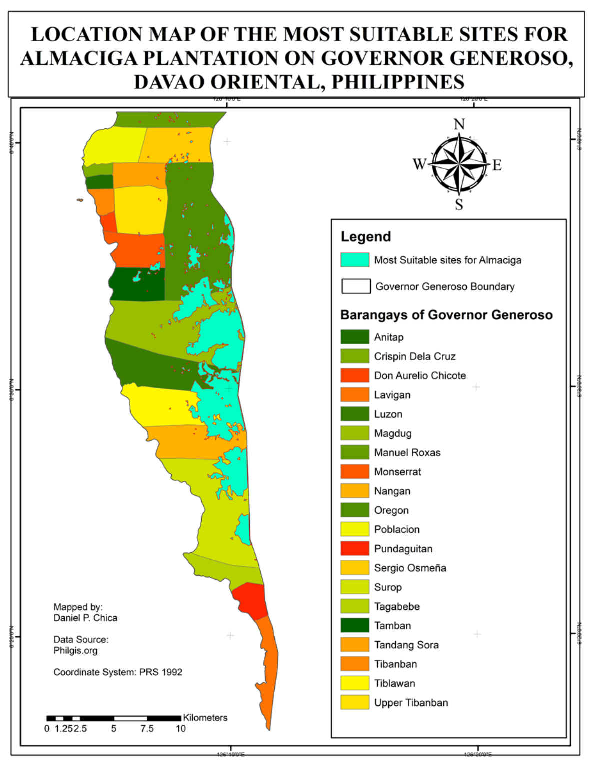

Figure 5. Location map of the most suitable sites for almaciga plantation in Governor Generoso, Davao Oriental, Philippines.

staking. On average, this costs around PhP 616.67 ha^{-1} for labor. The total cost for labor and seedlings is PhP 10,000.00 ha^{-1}. As the plantation will be established on areas that may have vegetation, the spacing used is 5 m x 5 m, resulting in 400 seedlings ha^{-1}. This planting density is lower than the planting density recommended by ERDB (2013), which is 4 m x 4 m with 625 seedlings ha^{-1} and results in higher cost. In Indonesia, *Agathis dammara*, a conspecific species of almaciga, is planted with a spacing of 4 m x 4 m (Setiawan *et al*. 2019). Site preparation is followed by the planting of the seedlings at the cost of around PhP 616.67 ha^{-1}. Thus, the total plantation establishment cost is PhP 11,233.33 ha^{-1}.

Table 3. Silvicultural practices and costs of almaciga plantation development in Governor Generoso, Davao Oriental, Philippines.

Year	Activities	Inputs required	Cost per ha (PhP ha^{-1})
0	Site preparation	Labor	1,233.3*
	Planting	Seedlings	10,000**
1	Weeding and brushing	Labor	2,690*
	Replanting	Seedlings	
2	Weeding and brushing	Labor	1,850*
3	Weeding and brushing	Labor	1,850*
4 onwards	None	None	None

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In year 1, weeding and brushing are conducted four times yr^{-1} at PhP 2,466.67 ha^{-1} yr^{-1}. A 10% seedling mortality rate as observed by key informants was used, adding PhP 223.33 ha^{-1} (cost of seedlings and labor) for a total cost of PhP 2,690.00 ha^{-1}.

In years 2 and 3, weeding and brushing are continuously done at a reduced frequency of three times a year, costing PhP 1,850.00 ha^{-1} yr^{-1}. Beginning the fourth year onwards, maintenance is no longer necessary. Therefore, no cost will be incurred. These cost data were used for the cost stream of the cash flow. Comparing the costs listed in the FMB TB 10-A, the labor cost in the site is only PhP 250.00 day^{-1}, which is lower than the labor cost used by FMB of PhP 370.00 day^{-1}. The seedlings in the study site cost PhP 25.00 each, higher than the cost of seedlings used in FMB TB 10-A of PhP 12.00 each.

The revenue of the almaciga resin was based on the market price (pick-up) of almaciga resin in the area of PhP 20.00 kg^{-1}. The practice in Governor Generoso and other areas like Palawan is that the buyer picks up the resin from the tapper's residence.

Profitability indicators

The cash flow developed for almaciga plantation development is shown in **Tables 4** and **5**. The revenue from resin yield was assumed to have a 100-year rotation, as trees in natural stands were estimated to be several hundreds of years old and remain a viable source of resin. At 10% discount rate, the NPV is PhP 160,233.40[2] ha^{-1}. and the BCR is 4.75, while the IRR is 19%. These indicate that the almaciga plantation is feasible because the NPV is positive, BCR is greater than 1, and IRR is greater than the discount rate of 10%.

Assuming that all the suitable areas in Governor Generoso, excluding the area under the PA (4,506.82 ha), will be utilized for almaciga plantation, the NPV from resin harvesting will be PhP 722,142,918.40. Watershed protection, soil and water conservation, biodiversity, and nutrient cycling are other benefits derived from the almaciga plantation aside from the resin. Additionally, the country's resin production can increase by up to 36,062,534.4 kg or 36,062.53 tons yr^{-1}, which is even higher than the resin the country produced in the past 10 years of 8,840 tons.

Table 5. Summary of the computed profitability indicators (NPV, BCR, IRR) after 100 years per hectare of almaciga plantation.

NPV (PhP ha^{-1})	160,233.40
BCR	4.74
IRR (%)	19.34

Sensitivity analysis

The sensitivity analysis results of the financial feasibility of almaciga plantation to changes in the unit price of Manila copal, plantation establishment cost, and interest rate are summarized in **Table 6**. The effects of changes in the factors varied in magnitude, but they negatively affected the NPV, BCR, and IRR of the almaciga plantation. The NPV of the almaciga plantation appears to be more sensitive to a decrease in the price of the Manila copal than to an increase in the cost of plantation establishment. This may be because the effect of price decrease is felt in all years when revenue is generated and for every unit (kg) of the resin. The magnitude of the effect of an increase in the discount rate is greater than the decrease in the price of the Manila copal. This may be because the discount rate affects the plantation's entire rotation period and yearly revenue. Still, the NPV under these scenarios remained positive, indicating that almaciga plantation remained profitable despite these shocks.

[2] *PhP 51.185 = USD 1.00*

Table 4. The cash flow of almaciga plantation per hectare basis.

Year	Annual resin yield tree^{-1} (kg)	Annual revenue ha^{-1} (PhP)	Annual cost ha^{-1} (PhP)	Discounting factor	Discounted annual revenue (PhP)	Discounted annual cost (PhP)
0	0	0	11233.33333	1.000000000	0	11233.33
1	0	0	2690	0.909090909	0	2445.455
2	0	0	1,850.00	0.826446281	0	1528.926
3	0	0	1,850.00	0.751314801	0	1389.932
4	0	0		0.683013455	0	0
5	0	0		0.620921323	0	0
6	0	0		0.56447393	0	0
7	0	0		0.513158118	0	0
8	0	0		0.46650738	0	0
9	0	0		0.424097618	0	0
10	0	0		0.385543289	0	0
11	0	0		0.350493899	0	0
12	0	0		0.318630818	0	0
13	0	0		0.28966438	0	0
14	0	0		0.263331254	0	0
15	0	0		0.239392049	0	0
16	0	0		0.217629136	0	0
17	0	0		0.197844669	0	0
18	0	0		0.17985879	0	0
19	0	0		0.163507991	0	0
20	0	0		0.148643628	0	0
21	0	0		0.135130571	0	0
22	15	120000	15480	0.122845974	14741.51683	1901.656
23	16	128000	16512	0.111678158	14294.8042	1844.03
24	17	136000	17544	0.101525598	13807.48133	1781.165
25	18	144000	18576	0.092295998	13290.62374	1714.49
26	19	152000	19608	0.083905453	12753.62884	1645.218
27	20	160000	20640	0.076277684	12204.42951	1574.371
28	20	160000	20640	0.069343349	11094.93592	1431.247
29	20	160000	20640	0.063039409	10086.30538	1301.133
30	20	160000	20640	0.057308553	9169.368528	1182.849
31	20	160000	20640	0.052098685	8335.789571	1075.317
32	20	160000	20640	0.047362441	7577.990519	977.5608
33	20	160000	20640	0.043056764	6889.08229	888.6916
34	20	160000	20640	0.039142513	6262.802082	807.9015
35	20	160000	20640	0.035584103	5693.456438	734.4559
36	20	160000	20640	0.032349184	5175.869489	667.6872
37	20	160000	20640	0.029408349	4705.335899	606.9883
38	20	160000	20640	0.026734863	4277.57809	551.8076
39	20	160000	20640	0.024304421	3888.707355	501.6432
40	20	160000	20640	0.022094928	3535.188504	456.0393
41	20	160000	20640	0.020086298	3213.807731	414.5812
42	20	160000	20640	0.018260271	2921.643392	376.892
43	20	160000	20640	0.016600247	2656.039447	342.6291

Table 4. The cash flow of almaciga plantation per ha basis (*Cont.*)

Year	Annual resin yield tree⁻¹ (kg)	Annual revenue ha⁻¹ (PhP)	Annual cost ha⁻¹ (PhP)	Discounting factor	Discounted annual revenue (PhP)	Discounted annual cost (PhP)
44	20	160000	20640	0.015091133	2414.581316	311.481
45	20	160000	20640	0.013719212	2195.073923	283.1645
46	20	160000	20640	0.012472011	1995.521749	257.4223
47	20	160000	20640	0.011338192	1814.11068	234.0203
48	20	160000	20640	0.010307447	1649.191528	212.7457
49	20	160000	20640	0.009370406	1499.265025	193.4052
50	20	160000	20640	0.008518551	1362.968205	175.8229
51	20	160000	20640	0.007744138	1239.062004	159.839
52	20	160000	20640	0.007040125	1126.420004	145.3082
53	20	160000	20640	0.006400114	1024.018185	132.0983
54	20	160000	20640	0.005818285	930.9256231	120.0894
55	20	160000	20640	0.00528935	846.296021	109.1722
56	20	160000	20640	0.0048085	769.3600191	99.24744
57	20	160000	20640	0.004371364	699.4181991	90.22495
58	20	160000	20640	0.003973967	635.8347265	82.02268
59	20	160000	20640	0.003612697	578.0315695	74.56607
60	20	160000	20640	0.00328427	525.483245	67.78734
61	20	160000	20640	0.0029857	477.7120409	61.62485
62	20	160000	20640	0.002714273	434.2836736	56.02259
63	20	160000	20640	0.002467521	394.8033396	50.92963
64	20	160000	20640	0.002243201	358.9121269	46.29966
65	20	160000	20640	0.002039273	326.2837518	42.0906
66	20	160000	20640	0.001853885	296.6215925	38.26419
67	20	160000	20640	0.00168535	269.6559932	34.78562
68	20	160000	20640	0.001532136	245.141812	31.62329
69	20	160000	20640	0.001392851	222.8561927	28.74845
70	20	160000	20640	0.001266228	202.5965388	26.13495
71	20	160000	20640	0.001151117	184.1786717	23.75905
72	20	160000	20640	0.00104647	167.4351561	21.59914
73	20	160000	20640	0.000951336	152.2137782	19.63558
74	20	160000	20640	0.000864851	138.376162	17.85052
75	20	160000	20640	0.000786228	125.7965109	16.22775
76	20	160000	20640	0.000714753	114.3604645	14.7525
77	20	160000	20640	0.000649775	103.9640586	13.41136
78	20	160000	20640	0.000590705	94.51278057	12.19215
79	20	160000	20640	0.000537004	85.92070961	11.08377
80	20	160000	20640	0.000488186	78.10973601	10.07616
81	20	160000	20640	0.000443805	71.00885092	9.160142
82	20	160000	20640	0.000403459	64.55350083	8.327402
83	20	160000	20640	0.000366781	58.68500076	7.570365
84	20	160000	20640	0.000333438	53.35000069	6.88215
85	20	160000	20640	0.000303125	48.50000063	6.2565
86	20	160000	20640	0.000275568	44.09090966	5.687727
87	20	160000	20640	0.000250517	40.08264515	5.170661

Table 4. The cash flow of almaciga plantation per ha basis (*Cont.*)

Year	Annual resin yield tree^{-1} (kg)	Annual revenue ha^{-1} (PhP)	Annual cost ha^{-1} (PhP)	Discounting factor	Discounted annual revenue (PhP)	Discounted annual cost (PhP)
88	20	160000	20640	0.000227742	36.43876831	4.700601
89	20	160000	20640	0.000207038	33.12615301	4.273274
90	20	160000	20640	0.000188217	30.11468456	3.884794
91	20	160000	20640	0.000171106	27.37698596	3.531631
92	20	160000	20640	0.000155551	24.88816906	3.210574
93	20	160000	20640	0.00014141	22.62560823	2.918703
94	20	160000	20640	0.000128555	20.56873476	2.653367
95	20	160000	20640	0.000116868	18.69884978	2.412152
96	20	160000	20640	0.000106243	16.99895434	2.192865
97	20	160000	20640	9.6585E-05	15.45359486	1.993514
98	20	160000	20640	8.78045E-05	14.0487226	1.812285
99	20	160000	20640	7.98223E-05	12.771566	1.647532
100	20	160000	20640	7.25657E-05	11.61051454	1.497756

Table 6. Factors in sensitivity analysis that affect the profitability of the almaciga plantation.

Influencing factor	Level of variation	Net present value (PhP ha^{-1})	Benefit–cost ratio	Internal rate of return
Decrease in Manila copal unit price	-10%	139,931.30	4.27	19%
	-30%	99,327.16	3.32	18%
	-50%	58,723.02	2.37	16%
Increase in plantation establishment cost	+10%	155,934.33	4.31	19%
	+30%	147,437.77	3.65	18%
	+50%	138,839.71	3.16	17%
Discount rate	11%	115,788.21	4.21	
	13%	59,874.21	3.17	
	15%	29,106.37	2.27	

CONCLUSION AND RECOMMENDATIONS

Based on the results, the study concludes that there are significant areas in Governor Generoso suitable for almaciga plantation development. The people in the area have technical knowledge and experience in growing almaciga trees. Resources needed for the plantation establishment, such as land, labor, and seedlings of almaciga are also available, indicating that developing almaciga plantations in the area is technically feasible.

Furthermore, the study found that developing almaciga plantations for resin production is financially profitable with an NPV of PhP 160,233.40 ha^{-1}, BCR of 4.75, and an IRR of 19%, which can provide positive net benefits to the resin tapping communities and to the environment. However, there is a need to improve the resin price and consider the tappers' opportunity costs in determining the price. Finding other buyers of almaciga resin who can offer a higher price may also be pursued. The profitability of the almaciga plantation appears to be more sensitive to a decrease in the price of the Manila copal than the increase in the cost of establishing the plantation.

More studies are needed on the biomass growth and yield and resin yield of almaciga in both natural forests and plantations. The methodology developed in this study may be used to construct an updated site-suitability map if more recent data become available. Additionally, considering other factors for the mapping of suitable sites, such as the distance from roads or trails, can also help to improve the map. This will also cause ease in the transportation of resin if a plantation is established.

Given that the population of almaciga in natural forests is threatened, developing almaciga plantations can contribute to the conservation of the species and at the same time secure the raw material requirements of the paint and varnish and other industries that use almaciga resin as raw material. However, the long production period may make this endeavor unattractive to private investors and susceptible to uncertainties such as natural calamities and an unfavorable change in laws and policies on almaciga resin harvesting. For these reasons, the government may be in the best position to develop almaciga plantations.

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LITERATURE CITED

Boer, E. & Ella, A. (2000) *Plant Resources of Southeast Asia.* Bogor, Indonesia: PROSEA Foundation.

Carandang, W. & Lasco, R. (1997) *Successful Reforestation in the Philippines: Technical Considerations. Mega Issues in the Philippine Forestry: Key Policies and Programs*.

Carating, R., Galanta, R., & Bacatio, C. (2014) *The Soils of the Philippines*. Springer Science & Business. ISBN: 978-94-017-8682-9 (eBook). doi:10.1007/978-94-017-8682-9

Centre for Sustainability PH Inc. and Forest Foundation Philippines. (2017) Almaciga Manual. Retrieved from: <http://www.forestfoundation.ph/almaciga-manual/>

DENR [Department of Environment and Natural Resources]. (2017) DENR Administrative Order No. 2017–11.

Dolos, K., Bauer, A., & Albrecht, S. (2015) Site suitability for tree species: Is there a positive relation between a tree species' occurrence and its growth? *European Journal of Forest Research*. doi:10.1007/s10342-015-0876-0

Ella, A. (2000) *Improved Tapping of Almaciga Tree for Sustained Resin Yield*. Forest Products Research And Development Institute (FPRDI). Laguna, Philippines.

Ella, A. (2018). *Valuable but Endangered Forest Tree Species in the Philippines*. Forest Products Research and Development Institute (FPRDI). Laguna, Philippines.

ERDB [Ecosystems Research and Development Bureau]. (2013) *Compilation of Selected Forest Species from Vol. Nos. 1–10, 1989*. Research Information Series of Ecosystems (RISE). Ecosystems Research and Development Bureau, Laguna.

Evans, J. (1992) *Plantation Forestry in the Tropics* (2nd Ed.). Oxford University: Oxford University Press.

FAO [Food and Agriculture Organization of the United Nations]. (1997) Asia-Pacific Forestry Outlook Study. Retrieved from: <https://www.fao.org/3/w7715e/w7715e01.htm.>

FAO [Food and Agriculture Organization of the United Nations]. (2000) The Global Forest Resources Assessment 2000 (FRA 2000). Retrieved from: <https://www.fao.org/3/y1997e/y1997e05.htm>.

FAO [Food and Agriculture Organization of the United Nations]. (2012) *State of the Worlds Forest 2012*. Rome, Italy: Food and Agriculture Organization of the United Nations.

FMB [Forest Management Bureau]. (2018) *Philippine Forestry Statistics*. Quezon City, Philippines.

FMB [Forest Management Bureau]. (2021) *Philippine Forest Cover*. Retrieved from: <https://forestry.denr.gov.ph/index.php/statistics/forest-cover>.

Fuess, L. & Zaiat, M. (2018) Economics of anaerobic digestion for processing sugarcane vinasse: Applying sensitivity analysis to increase process profitability in diversified biogas applications. *Process Safety and Environmental Protection* (115): 27–37. doi:10.1016/j.psep.2017.08.007

Gittinger, J.P. (1982) *Economic Analysis of Agricultural Projects*. USA: The Johns Hopkins University Press.

Housing and Land Use Regulatory Board. (2014) *CLUP Guidebook: A Guide to Comprehensive Land Use Plan Preparation* (Vol. 3).

Investment Coordination Committee. (2016) *Memorandum, Revisions on ICC Guidelines and Procedures (Updated Social Discount Rate for the Philippines)*. Philippines.

Kanowski, J., Catterall, C., & Wardell-Johnson, G. (2005) Consequences of broadscale timber plantations for biodiversity in cleared rainforest landscapes of tropical and subtropical Australia. *Forest Ecology and Management* 208(1–3): 359–372. doi:10.1016/j.foreco.2005.01.018.

Liu, D., Iverson, L., & Brown, S. (1993) Rates and patterns of deforestation in the Philippines: Application of geographic information system analysis. *Forest Ecology and Management* (57): 1–16.

Mordeno, M. (2019) *Almaciga: Lighting up Lives in Governor Generoso*. Mindanews. Retrieved from: <https://www.mindanews.com/special-reports/2019/08/almaciga-lighting-up-lives-in-governor-generoso-second-of-three-parts/#>

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., & Anthony, S. (2009) Agroforestry Database: a tree reference and selection guide version 4.0. Retrieved from: <http://apps.worldagroforestry.org/treedb/AFTPDFS/Agathis_philippinensis.PDF>

Setiawan, B., Lahjie, A., Yusuf, S., & Ruslim, Y. (2019) Assessing the feasibility of forest plantation of native species: A case study of *Agathis dammara* and *Eusideroxylon zwageri* in Balikpapan, East Kalimantan, Indonesia. Biodiversitas: *Journal of Biological Diversity* 20(9): 2454–2461. doi:10.13057/biodiv/d200904.

Shackleton, C., Delang, C., Shackleton, S., & Shanley, P. (2011) *Non-Timber Forest Products in the Global Context*. Springer-Verlag.