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Article

Financial analysis of a small scale *Pinus patula* Schiede ex Schltdl. *et* Cham. plantation

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Abstract:

There are hundreds of small *Pinus patula* plantations in the Mexican states of *Veracruz*, *Puebla*, *Tlaxcala*, and *Hidalgo*, among others. Nonetheless, their financial feasibility is rather unknown to date. By means of the Net Present Value (NPV), Benefit/Cost ratio (B/C), and Internal Rate of Return (IRR) indicators, the financial feasibility of a 3 000 m^2 *P. patula* plantation, 17 years old, whose production is to be used for making pulp and sawnwood, was assessed. Both costs, benefits and mensuration data were recorded along the project life, except for the first five and for the last three years. Costs for the initial five years were derived from interviews to the plantation owner. Costs and benefits during the last three years of the project were estimated from the plantation mensuration data and regional prices of the products projected. The NPV, B/C ratio, and IRR for the plantation were MX$ 37 959.00, 2.32 %, and 26.61 %, respectively. The costs and benefits that impacted the most the final financial balance of the project were those occurring at the early stages. Accordingly, the implementation of strategies to decrease costs and increase benefits during the initial stages of the project is advisable. Agroforestry systems, among others, may provide appropriate schemes in this direction.

Key words: Family plantation, forest plantation, pine, wood yield, financial profitability, net present value.

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Introduction

Commercial forest plantations (PFCs) in Mexico date back several decades; however, the massive impulse they received began in the late 1990s through the Program for Development of Commercial Forest Plantations (*Programa de Desarrollo de Plantaciones Forestales Comerciales,* Prodeplan) (Comisión Nacional Forestal, n/d). PFCs in Mexico still represent a deficient proportion regarding area compared to natural forests. They only participate with 5 % of the wood production concerning the production of the country's natural forests (Comisión Nacional Forestal, n/d).

The development of temperate climate plantations has been slow compared to what happens in the United States of America, Chile, South Africa, Colombia, New Zealand, Malaysia and many other Asian and European countries; where large areas of forest species have been established, including species of Mexican origin in many cases, such as *Pinus radiata* D. Don. and *P. patula* Schiede ex Schltdl. *et* Cham. (Muñoz *et al.,* 2010; Sánchez, 2013). Despite the above, in the states of *Puebla*, *Veracruz*, *Hidalgo* and *Tlaxcala*, mainly, there is a considerable number of commercial plantations of *P. patula* that vary from less than half a hectare to several hectares. Most of them come out from the initiative of peasants with small properties who trust that they will pay better dividends than those obtained from agricultural crops. Of course, the establishment of this type of plantations has been motivated, at least partially, by the program of conversion of agricultural soils of Conafor, which undoubtedly contributes to the financial success of the projects.

To date, reports of economic studies of this type of productive systems in Mexico are unknown, because they are small properties (“ejidos”) or parcels and most of the forestry activities are carried out by the plantation owner and members of his family. The lack of technical training on the subject is a common denominator in this context.

Therefore, the present study aimed to make an analysis of the financial profitability of the biological productivity and the transformation of the product (Roundwood) of a small plantation of *Pinus patula* located in *Huayacocotla, Veracruz*, which has not had external support and is representative of the great majority of those that are distributed in the region. From those that have been benefited by government subsidies, it would be expected that the level of profitability would be higher than the one determined in this case.

It is necessary to mention that the financial analysis was carried out *ex-post* for the most part, given that it is a plantation project still in force at the time the study described below was carried out. The above means that the majority of amounts, both expenses and income, are real, given that the respective records are available for 17 years, of 20 that the project will last.

Materials and Methods

Study area

The plantation of interest is located in the *ejido* of *Palo Bendito*, *Huayacocotla* municipality of, *Veracruz*, at 20°27' N and 98°29' W and an altitude of 2 460 m. The climate is temperate sub-humid, with rain in summer and frequent mists, with an average annual temperature of the coldest month (January) between 3 and 8 °C and the hottest month (May) higher than 16 °C. The average annual rainfall varies from 633 to 1 385 mm (Vásquez *et al*., 2015).

The soils in the study area are of sedimentary origin, mainly with shales and sandstones, with a general clay-clay texture. The superficial drainage is fast, while the internal one is slow due to the high concentrations of humus. The main soils are of the Luvic phaeozem type, with a layer rich in organic matter and nutrients and Pellic vertisols with clay and waterproof texture. The average slopes are 30 % (Domínguez *et al.,* 1997).

The main types of vegetation are the pine forest and the pine-oak forest. In the area adjacent to the plantation dominates the pine forest, being *Pinus montezumae* Lamb. and *P. pseudostrobus* L. the dominant species, although there are isolated trees of *P. patula* and *P. leiophylla* Schiede ex Schltdl. & Cham.The main types of vegetation are the pine forest and the pine-oak forest.

Most of the forest management in the region is based on Seed trees; however, because the advantages of artificial repopulation are known in terms of shortening the turn, as well as the high growth rates of *P. patula,* regeneration is established immediately after the regeneration cutting through the planting of same species.

Establishment and management of the plantation

The plantation studied has an extension of 3 000 m^2 and was established by" the so-called individual-hole system during the rainy season (July) of 1998, with a spacing of 2.5 m between trees and rows. From then on, it was uncared-for and weeds, especially *Baccharis conferta* Kunth, which invaded the site and dominated the pines, could exceed them in height until the end of 2003. After this year, the individuals of *B. conferta* gradually succumbed under the pine canopy. In 2009, a clean operation was implemented to remove remnants of this herbaceous species with pruning of up to 7.5 m in height (three logs of 2.5 m in length), a very light experimental thinning (only in some experimental plots) and a commercial thinning to the end of 2015. The regeneration cutting will be carried out in 2018 when the trees are 20 years old, as proposed by Santiago *et al.* (2015) for the forest species in the *Zacualtipán* region, *Hidalgo*.

Determination of expenses and income

The costs that were incurred from the establishment of the plantation (1998 to 2003) were estimated based on questionnaires applied in the community, about the prevailing wages in the area in the corresponding years, as well as by yield estimates per day in the activities carried out in that period. From 2003 and until 2016, the costs of each of the activities carried out in the plantation were recorded on time. With this experience during the period above, estimates of the activities planned for the 2016-2018 period were made. In this way, the flow of project expenditures was established, in which an annual increase in the minimum wage of 3.5 % was considered, as occurred from 2010 to 2014 (Moreno and Garry 2015).

The economic benefits of the project were established based on the activities that generated or will generate some commercial product, corresponding to two thinning harvests and one regeneration cutting using the clearcutting system. The value of the wood resulting from the thinning harvests made in 2012 and 2015 was recorded at the time. In the case of the volume of wood to be generated with the cutting at the end of the shift (2018), estimates were made based on the dendro-epidometric records of the plantation of the estimated production of sawn wood (board feet) based on the Doyle rule. The value of the average current price obtained from several prices of sawn timber in the region between *Texcoco*, *Estado de México*, *Tulancingo*, *Hidalgo* and *Huayacocotla*, *Veracruz*, in September 2015 was used.

The sale of pulpwood for paper was also considered in the project's income. This wood comes from the pieces with diameters larger than 13 cm and minimum length of 1.27 m.

The wood volumes of the plantation were used to estimate the income based on annual measurements of the diameter at breast height (*DBH*) of all trees during the 2009-1017 period. The height (*A*) of the trees was also calculated from the *DBH*, by the parameterized Gompertz model for *Pinus patula* (Santiago, 2009). From *DBH* and *A*, the volume (*VOL*) of the stem of each of the trees was estimated from 2009 to 2016 using the model generated by Arteaga (2003) for the species under study. Increases in this item (*IVOL*) with the annual volumes were estimated.

Based on the volumetric stock in the plantation, from 2009 to 2015, a model was developed to represent the accumulation of wood volume over time and apply that model after the implementation of the thinning of the end of 2015, even though the model could underestimate the volume of wood after thinning, given that with this treatment, the resources of the site are redistributed in a smaller population of trees, which improves growth (López and Flores, 2016).

Data analysis

The costs and the gross income of the project throughout its validity were discounted at year zero (0) of the project, with the *VA* function (current value) of EXCEL Ver. 2013 (Microsoft Office, 2013). The discount rate of 12 % was the same used by López and Musálem (2007), which also corresponds to that by Cubbage *et al.* (2011) for forestry projects in Mexico. Based on the discounted amounts of expenditures and income from the project, the calculations of the financial indicators Net Present Value (*NPV*), Benefit Cost Ratio (*B/C*) and Internal Rate of Return (*IRR*) were made (Sunday *et al*., 2013). In addition, an analysis of the forestry activities that have the greatest financial impact on the project was made.

The formula used for the update (VA) of the gross income (G) and expenses (C) of the project was:

$$VA=VF/(1+r)^n \text{............}(1) \qquad \text{(Lutz, 2011)}$$

Where:

VA = Present value of one expense (C_0) or income (G_0); ($MX)

VF = Future value of one expense or income; ($MX)

r = Discount rate (%)

n = Period in which the expense or income occurred; (year)

From the expenses or incomes updated to the year zero, the NPV, B/C and IRR were calculated through the following equations:

$$NPV=\sum_{n=1}^{t}(G_0) - \sum_{n=1}^{t}(C_0)$$

Where:

NPV = Net present value of the project; ($MX)

n = Period (annuity) in which one expense or income occurs

t = Annuity corresponding to the end of the silvicultural rotation period of the plantation

G_0 = Gross profit discounted to the year zero; ($MX)

C_0 = Economic expenses discounted to the year zero; ($MX)

$$B/C= \sum_{n=1}^{t}(G_0) / \sum_{n=1}^{t}(C_0)$$

Where:

B/C = Cost/benefit relationship

n = Period (annuity) in which one expense or income occurs

t = Annuity corresponding to the end of the silvicultural rotation period plantation

G_0 = Gross profit discounted to the year zero; ($MX)

C_0 = Economic expenses discounted to the year zero; ($MX)

In the case of the IRR, the calculation is made by trial and error, based on the NPV formula, which changes the discount rate (r) during the update process (equation 1), until achieving a NPV = 0 (Lutz, 2011). However, at present there are various computer programs for calculation in practical form; in this case, the "IRR calculator" located on the https://financial-calculators.com/irr-calculator website was used (IRR-Calculator, 2017).

Results and Discussion

Epidometric development of the plantation

Figure 1 shows the values of real volume and modeling per year during the 2009-2015 period. There are no epidometric records of the plantation before 2009. The trend of the accumulation of timber volume of stems was linear, which reached an increase of 38.39 m^3 ha^{-1} $year^{-1}$ (Figure 1), a similar value to that recorded by Sáenz *et al.* (2011) for pine plantations in *Michoacán* and even higher to that mentioned by Webb (1980, quoted by Muñoz *et al*., 2010).

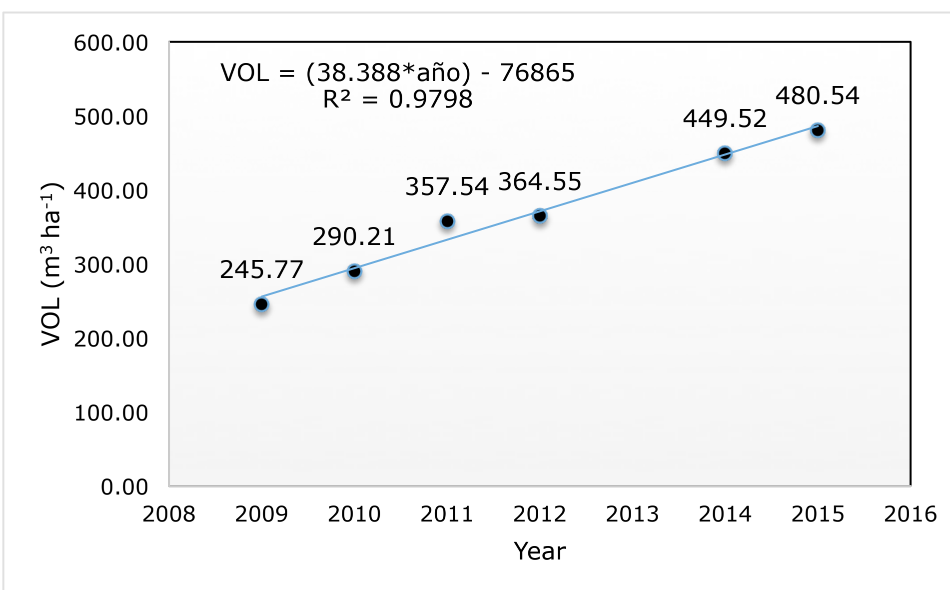


Figure 1. Actual volume and modeling in the plantation of *Pinus patula* Schiede ex Schltdl. *et* Cham.in *Huayacocotla*, *Ver*acruz, during the 2009 - 2015 period.

Figure 2 shows volume increases from 2009 to the scheduled completion of the project (2018). The figure indicates that the annual volume increased until 2011. In 2012, an experimental thinning was carried out in the plantation, so the increments decreased in that year. However, one year after (2013), the volume increase reached a similar level to that of 2010 and continued such tendency; however, in 2015 a decrease was observed, which is ascribed to the high density of trees, which indicates that the plantation required a cutting that year. This assertion coincides with the finding of Vásquez (2014), who determined that the net primary productivity (NPP) of that plantation began to decline and recommended the implementation of a thinning.

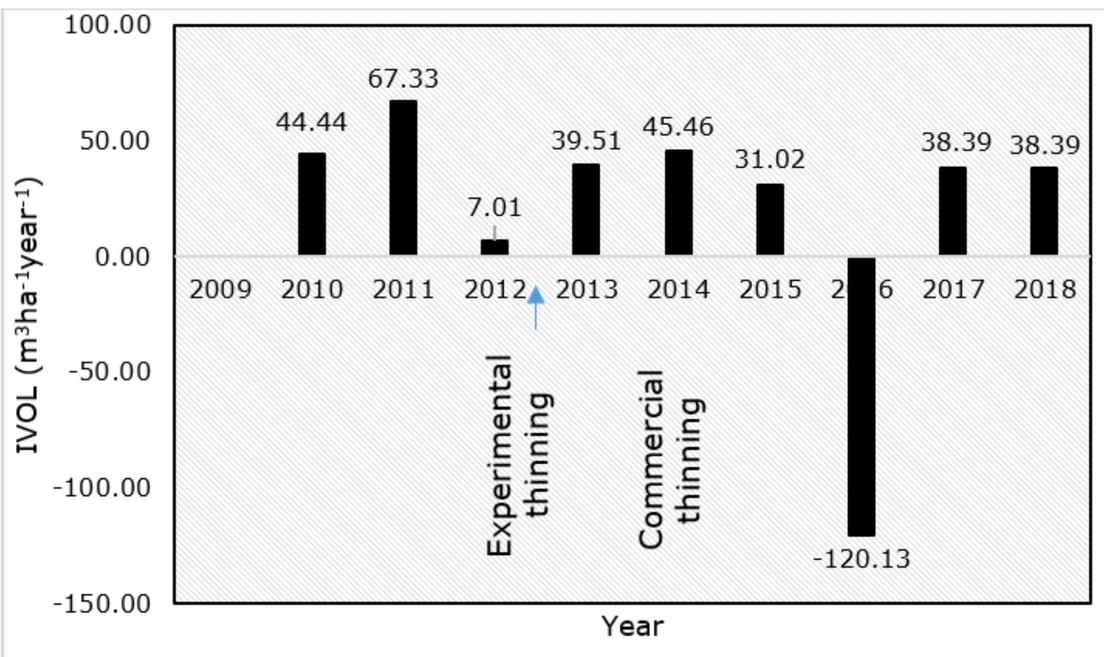
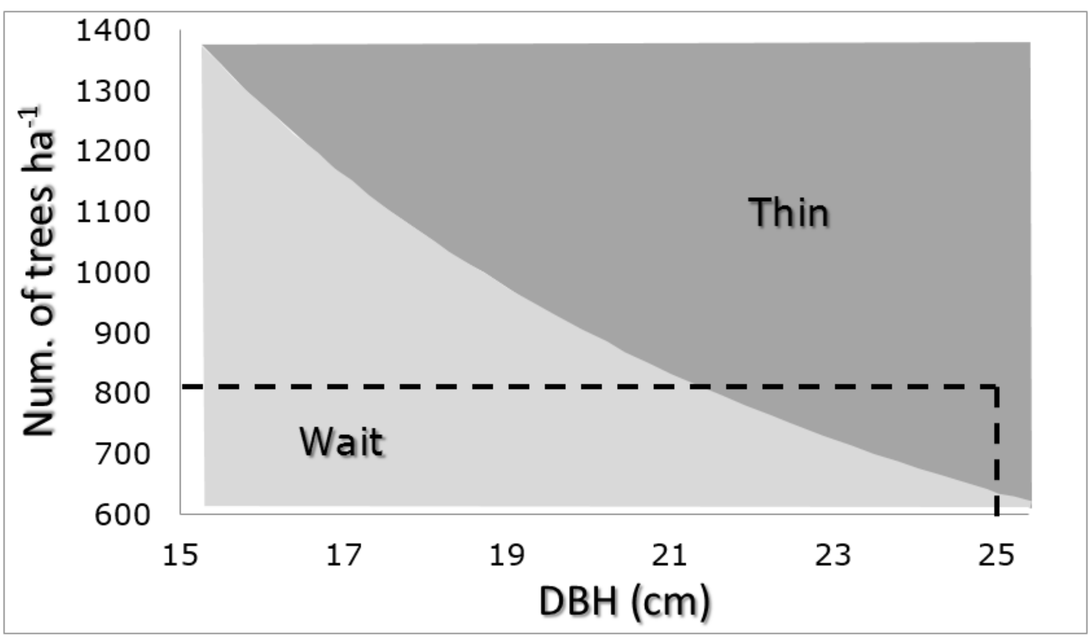


Figure 2. Behavior of the annual volume increase (IVOL, $m^3ha^{-1}year^{-1}$) recorded between 2009 and 2018, including the thinnings in 2012 and 2015 and predictions of the increase in volume between 2016 and 2018 in the plantation of *Pinus patula* Schiede ex Schltdl. *et* Cham. in *Huayacocotla, Veracruz*.

The prescription of a thinning in 2015 is also supported in the density guide for pine plantations for timber production, proposed by Traugott and Dicke (2006) (Figure 3). The plantation under study had 813 trees ha^{-1} in 2015 and an average DBH of 25 cm. According to the aforementioned density guide, adapted to the metric system, the interception of these values falls within the "thinning area" since it is located above the threshold line between thinning and no-thinning (Figure 3).

Based on the plantation volume prediction model (Figure 1), for 2017 and 2018 it is expected that the volumetric increases reach at least the average level that the plantation had before the thinning (38.39 m^3 ha^{-1} yr^{-1}, Figure 2); although theoretically, increases in volume should reach levels above the means, given the improvement in the availability of resources (water, nutrients, light, air and underground spaces, among others) per tree remaining after the thinning (Rodríguez *et al*., 2011).



Source: Modified from Traugott and Dicke (2006).

Figure 3. Decision graph to "thin or wait".

Figure 4 shows the volumes recorded annually for the period between 2009 and 2015, as well as the volumes predicted for the period after commercial thinning.

According to Figure 4, in 2015 a total of 120.14 m^3 ha^{-1} (480.54-360.40 m^3 ha^{-1}) was obtained as a result of commercial thinning and in 2018, a total of 437.18 m^3 ha^{-1} will come from the regeneration cutting. From the conversion, using the Doyle rule, 1 365 fb of Roundwood from the 2015 thinning was obtained, while from the regeneration cutting (in 2018), it is estimated a total of 8 944 fb of sawn wood. Additionally, logs of 1.27 m long and a low diameter larger than 13 cm, once stacked, produced a total of 6 m^3 for the 2015 thinning and will produce 61.5 m^3 for the regeneration cutting in 2018, volumes that will be commercialized for paper pulp.

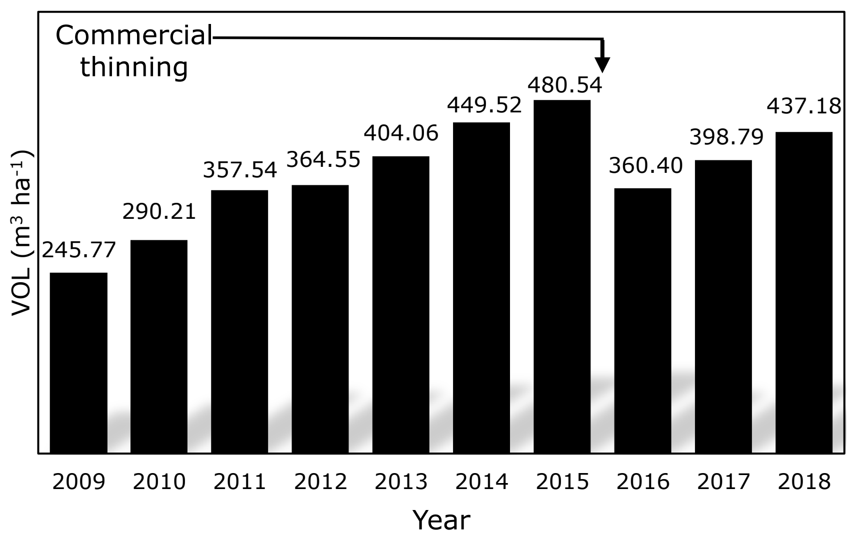


Figure 4. Volumetric stock registered in the plantation for the period 2009-2015 and estimated for the period 2016-2018, after a commercial thinning in 2015.

Financial analysis of the plantation

Tables 1 and 2 show the not-updated and updated flows, respectively, of the project's expenditures. The second indicates that the activities that impact the project's costs most intensively are payment for technical forest services, followed by pruning. As Brown (2000) generalizes for all types of forest plantations, the costs that most affect project expenditures are those that are made in the first years; such is the case of pruning, which added to technical services, raise the initial costs.

Table 1. Non-updated expenditures flow for the *Pinus patula* Schiede ex Schltdl. *et* Cham. plantation in *Huayacocotla, Veracruz.*

Year Num.	Year	Non-updated amounts per acomplished activities ($MX ha^{-1})									Total ($MX.ha^{-1})
		1	2	3	4	5	6	7	8	9	
0	1998	667							2 000		2 666
11	2009		1 300		1 667				2 000		4 967
12	2010			15 000	1 667						16 667
13	2011				1 667						1 667
14	2012				1 667	5 333					9 000
15	2013				1 667						1 667
16	2014				1 667						1 667
17	2015				1667		6 667	6 381	2 000	7 547	24 261
18	2016				1 667						1 667
19	2017				1 667						1 667
20	2018				1 667		13 333	41 812	3 000	72 234	132 046
Total		667	1 300	15 000	16 670	5 333	20 000	48 193	11 000	79 781	107 160

1 = Establishment of the plantation; 2 = Cleaning; 3 = Hand-made pruning up to 7.5 m high; 4 = Dendrological assessment; 5 = Experimental thinning and piece cutting; 6 = Commercial thinning and final harvest (felling and piece cutting); 7 = Sawing cost; 8 = Forest technical services; 9 = Products transportation.

Table 2. Discounted expenditures flow for the *Pinus patula* Schiede ex Schltdl. *et* Cham. plantation in *Huayacocotla, Veracruz* at a 12 % discount rate for the horizon of the project.

Year Num.	Year	Discounted amounts per accomplished activities ($MX ha^{-1})									Total ($MX.ha^{-1})
		1	2	3	4	5	6	7	8	9	
0	1998	667							2 000		2 667
11	2009		374		479				575		1 428
12	2010			3 850	428						4 278
13	2011				382						382
14	2012				341	1 091			409		1 842
15	2013				304						304
16	2014				272						272
17	2015				243		971	929	291	1 099	3 533
18	2016				217						217
19	2017				193						193
20	2018				173		1 382	4 335	311	7 488	13 689
Total		667	374	3 850	3 032	1 091	2 353	5 264	3 586	8 587	28 805

1 = Establishment of the plantation; 2 = Cleaning; 3 = Hand-made pruning up to 7.5 m high; 4 = Dendrological assessment; 5 = Experimental thinning and piece cutting; 6 = Commercial thinning and final harvest (felling and piece cutting); 7 = Sawing cost; 8 = Forest technical services; 9 = Products transportation.

The estimates made to determine the average price of pine sawn wood ($ MX fb^{-1}) in the regions of *Texcoco, Estado. de Méx*ico, *Tulancingo, Hidalgo* and *Huayacocotla, Ver*acruz, indicated that it was $ MX 12.75 for September 2015. In a similar way, in the *Huayacocotla* region, pulpwood was rated at $ MX 750.00 per m^3, stacked at the bottom of the road. Therefore, Table 3 indicates that the most important revenues in the plantation come from commercial thinning and regeneration cutting. These two income concepts were verified during the last years (years 17 and 20 out of 20), which means that when they are discounted to year zero, they have little impact on the benefits associated to the project. According to the former, it is deduced that what is recommended for this type of projects in so far as they are current, is to achieve a design in which the first few years have the minimum possible costs and even generate income. This strategy is also suggested by Brown (2000).

Table 3. Non- discounted and discounted incomes flow for the *Pinus patula* Schiede ex Schltdl. *et* Cham. plantation in *Huayacocotla, Veracruz* at a 12 % discount rate for the horizon of the project.

Year Num.	Year	Non- discounted uptaded amounts ($MXha^{-1})		Discounted amounts ($MXha^{-1})		Discounted total ($MXha^{-1})
		1	2	1	2	
0	1998					0
11	2009					0
12	2010					0
13	2011					0
14	2012	4 250		870		870
15	2013					0
16	2014					0
17	2015	58 008	14 112	8 448	2 055	10 504
18	2016					0
19	2017					0
20	2018	380 112	154 200	39 405	14 318	53 723
Total		442 370	168 312	48 723	16 374	66 764

1 = Sawn wood; 2 = Pulp wood.

The preceding can be achieved, for example, by incorporating high tree densities to carry out commercial thinning in the first 5 to 10 years in which poles or paper pulp can be sold. Also, with a high-density system, it is possible to avoid activities such as cleaning and pruning at the beginning of the project, which would reduce expenditures for the execution of those activities.

Another option to generate income in the first years of the project is the implementation of agroforestry systems. In this case, the density of the trees should be so low that it allows the cultivation of agricultural species that provide economic resources during the first years before canopy closure occurs (Conafor-UACh, 2013). López and Musálem (2007) evaluated several alternatives of this type of systems and found that some of them, especially those that include profitable agricultural crops such as coffee, peanuts and in some cases corn interspersed with red cedar (*Cedrela odorata* L.), improved or kept the profitability of the projects and increased their social acceptance.

Similarly, Romo *et al.* (2012) recorded that in *El Fortín*, *Atzalan* municipality, *Veracruz*, the agro-silvo-pastoral system designed through the combination of melina (*Gmelina arborea* Roxb.), maize, insurgent grass (*Brachiaria brizantha* (Hochst ex A. Rich.) Stapf and cattle provided the best financial indicators.

The combination of timber trees with the cultivation of Christmas trees can also be an option to generate income during the first 8 to 12 years, mainly, but not exclusively, in temperate climates. In this case, the density of wood for trees must be low so that the Christmas trees receive enough solar radiation and develop balanced crowns.

At the end of the project, the net present value of the project was positive (*NPV* = \$ MX 37 959.00 ha^{-1}) (Table 4), which indicates that the implementation of the studied plantation is profitable from the financial point of view (Holopainen *et al*., 2010). The above is also confirmed by the benefit-cost ratio (B/C), which resulted in a value of 2.32 (Table 4). This means that each *peso* invested in the project is recovered and additionally \$1.32 per *peso* invested. The value found for the *B/C* ratio is comparable to those obtained by López and

Musálem (2007) for agroforestry systems or plantations of red cedar (*C. odorata*), *Primavera* (*Roseodendron donnell-smithii* (Rose) Miranda) or cedar walnut (*Juglans pyriformis* Liebm.), in *Los Tuxtlas*, *Veracruz*, and even higher than those determined for the agroforestry system recommended by Romo *et al*. (2012).

Table 4. Net present value a ctual value and beneft/cost ratio of the *Pinus patula* Schiede ex Schltdl. *et* Cham. plantation of *Huayacocotla*, *Veracruz*.

Financial variable	Amount ($MX)	***NPV* ($MX)**	***B/C* (%)**	***IRR* (%)**
Updated benefits	66 764	37 959	2.32	26.61
Updated costs	28 805			

The *IRR* resulted in 26.61 %, which implies that only with a discount rate as high as that, the *NPV* would be zero; however, given that the discount rate is much lower (12 %), the financial viability of this project is right.

The indicators show that the project is financially viable, even though in the quantification of income by sawing it was considered as the price of wood, the second class. This reduces the estimated margin of profit; however, pruning has been applied to the plantation in such a way that it guarantees the production of a considerable amount of first-class timber, which means higher product prices, that, eventually, will increase the *NPV,* the *B/C* ratio and the *IRR.*

On the other hand, this analysis did not include financial support from government sources (subsidies). If they If they were taken into account, provided that they are feasible to achieve for this type of project, it is highly probable that the financial indicators will improve substantially.

Conclusions

At the end of the project, the financial balance will be positive, since it will generate gross revenues equivalent to 2.32 % concerning costs; they support a discount rate as high as 26.61 % before the *NPV* takes negative values. According to the current discount rate (12 %) and the value of the *IRR* (26.61 %), the project is financially profitable. The profitability of the project can be greater with the adoption of some agroforestry system.

The financial evaluation of this analysis highlights the fact that the productivity conditions of the site are very favorable for timber production through the establishment of forest plantations. It is entirely feasible to increase the profitability of this type of projects by reducing the silvicultural rotation time for the selected species, and to associate the production of the timber obtained in the plantation with manufacture of higher-value products.

From the above, the establishment of similar plantations in the study area is highly recommended, given that they constitute a cost-effective alternative for small properties or *ejido* plots. On the other hand, the costs of establishment and maintenance, generally can be covered by the owners of the land, even in the absence of government subsidies. This production alternative opens a new horizon for incomes to local inhabitants, which adds to agriculture and local livestock.

Conflict of interest

The authors declare no conflict of interest.

Contribution by author

Miguel Ángel López López: financial data registration and analysis, writing and correction of the manuscript; Miguel Caballero Deloya: data analysis and review of the manuscript.