Costs and Benefits Analysis of *Aquilaria* Species on Plantation for Agarwood Production in Malaysia

Mohd Farid Mamat
Forest Research Institute Malaysia
52109 Kepong Selangor
paridms@frim.gov.my

Mohd Rusli Yacob
Faculty of Economics and Management
University Putra Malaysia
43400 UPM Serdang
mroy@econ.upm.edu.my

Lim Hin Fui
Forest Research Institute Malaysia
52109 Kepong Selangor
limhf@frim.gov.my

Alias Rdam
Faculty of Economics and Management
University Putra Malaysia
43400 UPM Serdang
alias@econ.upm.edu.my

Abstract

The establishment of Aquilaria plantation for agarwood production has been regarded by the planters as a green 'gold mine' of the future. This study examines the costs and benefits of planting Aquilaria spp. for agarwood production. The analysis shows that whether planting Aquilaria spp. integration with banana (Musa spp.) or planting Aqualaria spp. as a single crop for agarwood production, both options are viable. An investment return for planting Aquilaria spp. integrated with banana (Musa spp.) on 1,000 hectares of land is higher with an internal rate of return (IRR) of 54.85% compared with 38.49% for a single crop Aquilaria plantation. The Net present value (NPV) of investment at a 10% discount for 1,000 hectares integrated planting is RM185.6 million (1 RM=USD0.32 in 2008) while the option involving single crop Aquilaria plantation for agarwood production is RM153.6 million.

Keywords: Cost Benefits Anaylsis, net present value, Agarwood, production, Malaysia, Aqualaria species

Introduction

Agarwood is perhaps the most prized non-timber forest product traded in the international market. The establishment of forest species producing agarwood is gaining attention at national and local levels as the resources from the natural forest are depleting over the years. Planters see this type of plantation as green 'gold mine' of the future, if there is a breakthrough in inoculation technology. Agarwood (also known as gaharu, aloes wood, eagle wood, oud, chen-xiang, kalambak among other common names) is a fragrant wood that has been traded for a long time for its use in religious, medicinal and aromatic preparation.

It is produced from the resinous, fragrant and highly prized heartwood of species of *Aquilaria, Aetoxylon* (*A. symeatalum*) and *Gonystylus* of the family Thymelaeaceae. The agarwood producing tree species are found from India eastwards to Southeast Asian countries (such as Vietnam, Thailand, Malaysia, and Indonesia) to the island of New Guinea (Zich & Compton 2002). The production of agarwood is uncertain and it is estimated that only 10% of the *Aquilaria* trees in the forest may contain agarwood (Gibson 1977 cited in Donovan & Puri 2004). In Malaysia, agarwood is used traditionally for treating stomach pains, in pregnancy, after delivery, fever, rheumatism, body pains, women diseases and dropsy (Gimlet 1930; Burkill 1966). Historical record showed that agarwood was harvested and traded in Peninsular Malaysia before 684 CE (Nik Hassan 1998). The harvesting of tree species for agarwood persists until today.

In the Middle East, agarwood is a symbol of status, wealth and hospitality. An important use of agarwood is the production of incense, the most prized of all incenses. In Middle East, oudh (Arabic word for agarwood) is burnt to release the unique scent and it is a symbol of status, wealth and hospitality (Chang *et al.* 2002). Agarwood is also used as an ingredient in Ayurvedic, Tibetan, Chinese and other traditional Asian medicine. It is also used in the perfume and toiletry products such as soap and shampoo (Chang *et al.* 2002).

Because of its fragrant smell, agarwood has shown a wide range of uses. Both the wood and oil are highly prized for the scent produced. The scent is released on burning the wood. Among the uses of agarwood are shown in Table 1.

Insert table (1) about here

The main attraction for agarwood harvesting is its high prices. Grade "A" agarwood fetched about RM1,000 per kilogramme in 1985 and this increased to RM14,000 (1 RM=USD0.32 in 2008) per kilogramme in 2008 at the local level. However, the same Grade A agarwood fetches as high as RM16,000 in metropolitan Kuala Lumpur and RM25,000 in Dubai. When agarwood chips are processed into oil, the agarwood oil was sold at USD30,000 per kg (*Nanyang Siang Pau* 15 August 2005). The reason for the general price increase of various grades of agarwood is the increasing international demand on the one hand and decreasing agarwood supply on the other. Other than agarwood chips, agarwood oil is also exported in recent years. The price of agarwood oil also vary from RM350 to RM1,500 per tola (12 ml) as sold in shops in Kuala Lumpur.

Methodology

This study assesses the costs and benefits of planting *Aquilaria* spp. for agarwood production integrated with banana (*Musa* spp.) on commercial plantation and planting *Aquilaria* spp. as a mono crop. It focuses on developing plantation system, followed by estimating the costs and benefits for the species planted. Based on the costs and benefits estimated, the feasibility for the various options is examined. This feasibility analysis employs three main economics tools i.e. the net present value (NPV), benefit cost ratio (B/C ratio) and internal rate of return (IRR) of all the possible systems.

Net present value (NPV)

The term net present value is usually computed by finding the difference between the present worth of the benefit stream minus the present worth of the cost stream. It also is the sum of all years' discounted after-tax cash flows. In other words, the net present value is the present value of income generation by the investment (Gittenger, 1982). In evaluating a single project, the project would be carried out if the net present value is positive. It is not worth implementing if otherwise. In the case where evaluation of more than one project is involved, selection should be made for the highest internal rate of return as well as net present value with high benefit cost ratio. The formula use for calculating the net present value is as below;

Net present value:

$$= \Sigma (B_t - C_t)/(1 + i)^t$$

Benefit cost ratio (B/C ratio)

Net present value tells us how much the expected present profit could be earned from the investment but it does not reveal the proportion of total benefits against the total costs invested. To do this, benefit cost ratio analysis is the right financial tool to be employed. The project would be carried out if the benefit costs ratio is more than one. In a situation where they're more than one project, then the highest benefit cost ratio is preferable.

The formula for calculating benefit costs ratio as shown below;

$$= \Sigma \{B_t /(1 + i)^t\}/\Sigma \{ C_t/(1 + i)^t \}$$

Internal rate of return (IRR)

Apart from the net present value and benefit cost ratio analysis, internal rate of return is another financial tool to determine the integrated planting. Internal rate of return is measured when the discounted total benefits minus discounted total cost is equal to zero. The investment should only be carried out if the internal rate of return is more than capital cost interest rate (i.e. bank loan interest rate charged). The mathematical formula for the above financial tools can be summarized as follow;

Internal rate of return:

$$=\Sigma\{ (B_t - C_t)/(1 + i)^t \} = 0$$

Feasibility Analysis of Aquilaria Plantation

This section highlights the planting activities and the various costs involved in the establishment and management of *Aquilaria* spp. plantings based on the experiences of established forest plantation in Malaysia and some are assumption values. Two options of forest plantation are examined *viz*:

- Integrating timber species (*Aquilaria* spp.) with agriculture crop (*Musa* spp.) - Aquilaria plantation for agarwood production as the main crop with banana (*Musa* spp.) as the secondary product
- *Aquilaria* plantation - Plantation for agarwood production only

Integration croping 'agroforestry' is actually the combination of agriculture and forestry technologies to foster integrated, optimal and sustainable land-use. It is also a production technique that combines both agriculture and forestry on the same piece of land to fully utilise the resources of sunlight, water and nutrition (Najib Lotfy *et al*. 1999). In addition, integrated plantation land-use system introduces the intentional integration of different tree species with annual crops and/or livestocks. The purpose is to get higher productivity, higher economic returns and better social benefits on a sustained basis than those obtained from monoculture on the same unit of land.

Cost associated with the plantation

For the purpose of this discussion, the cost discussed is based on 1,000 hectare plantation project which involves individual planters. Costs involved in this analysis were adopted from a few well-established companies involved in forest plantation and some are assumption values.

The costs discussed here are based on 7-year (with different cycle of harvest depending on the species) rotation. The costs for a plantation project can be classified into several categories as shown below:

a. Capital expenditure
b. Maintenance costs
c. Administration and operational cost

The total estimated expenditure for capital and for administration and operational costs of 1,000 hectare integration of two species (*Aquilaria* spp. and *Musa* spp.) are RM145,145,518. Of the RM145,145,518, RM118,115,518 is allocated for administration and other operational costs, while the balance fall under the capital expenditure. The costs under capital expenditure include the development cost (i.e. land preparation, planting, seedling and side dressing), infrastructure and development, transportation and equipment and building and amenities. The total capital expenditure of planting 1,000 hectares integration species (*Aquilaria* spp. and *Musa* spp.) with a 7-year rotation is RM27,030,000 (about 15% of the total cost of running the plantation, which is RM183,625,110). Of the total RM27,030,000, RM21,403,000 is allocated for the initial development (i.e. felling and land clearing, planting, planting material and side dressing), RM4,919,000 for infrastructure and RM708,000 for transportation and equipments. A detail breakdown of the capital, administration and operational costs is given in Table 2 and 3.

Insert table (2) about here

Insert table (3) about here

In-terms of maintenance costs, the most expensive maintenance activity is the supply of fertilizer, which cost RM17,944,000. Detail assumption used is shown in Table 4. The estimated total maintenance cost of planting 1,000 ha integration species with 7-year rotation, which consists of weed control, fertilizer, pest and diseases control, road maintenance, vehicle maintenance and source of fuel for vehicle is RM21,786,400 (Table 5). Table 6 shows the other contribution costs of 1,000 ha integrated plantation.

Insert table (4) about here

Insert table (5) about here

Insert table (6) about here

Revenues associated with the plantation

Agarwood from *Aquilaria* spp. will have one cycle of harvest after 7 years of planting. With 1,000 ha, it is assumed that only 60% trees that can produce agarwood rasin. One hectare is planted with 833 trees, therefore at the end of seven years, only 500 trees are expected to produce agarwood rasin. In addition, each tree is estimated to produce agarwood of 1,000 gram. Therefore, one hectare estimated to produce 500 kg agarwood resin.

Production of agarwood by inoculation is likely to yield grade C1 agarwood, therefore the price is not high, but this is an estimation only. There is a possibility that it will produce a better quality. For the the purpose of this study, it is assumed that the yield (agarwood) can be sold at RM1,000 per kilogram. The 1,000 ha plantation is estimated to produce 500 tonnes of agarwood and generate total revenue of RM500,000,000 (Based on the estimated market price of RM1 million per tonne or RM1,000 per kilogram).

For banana (*Musa* spp.), total trees planted is 1,099 trees per ha. The trees can produce yield up to year 4, with the first harvest after 12 months of planting followed by 8 months for second, third and fourth harvest. Assuming 5% mortality rate, one hectare plantation (integrated with *Aquilaria* tree) can produce 29,232 kg of banana.
With 1,000 hectares plantation, is estimated to produce 29,232 tonnes of banana per cycle and generate a revenue of RM26,308,800 (Based on the estimated market price of RM900 per tonne). Total revenue generated (considering four cycle of harvest) is estimated at RM105,235,200. Total revenue of RM605,235,200 (Table 7) is estimated for 1,000 hectares of *Aquilaria* spp. with 7-year rotation and intercropped with banana (*Musa* spp.)

The total revenue or cash inflow for 1,000 hectares of *Aquilaria* spp. with a 7-year rotation and intercropped with banana (*Musa* spp.) is slightly better than that for 1,000 hectares of *Aquilaria* spp. as a single crop. The difference is shown in Table 7. The difference between the two options is mainly due to additional short cycle income from banana (*Musa* spp.). On the other hand, the net cash inflow for 1,000 hectares of *Aquilaria* spp. intercropped with banana (*Musa* spp.) is RM422 million compared to RM380 million for planting *Aquilaria* spp. solely. This indirectly indicates that 1,000 hectares of *Aquilaria* spp. intercropped with banana (*Musa* spp.) is a better choice than planting *Aquilaria* spp. as a single crop.

Insert table (7) about here

Financial assessment of the plantation project

Net present value (NPV), internal rate of return (IRR) and benefit-cost ratio (B/C ratio) are used to evaluate the financial feasibility of the plantation project. All costs incurred and revenues gained from the project are discounted to present value for both NPV and IRR. Hence, a discounted rate of 10% has been used as the proximity rate of capital loan in Malaysia.

For 1,000 hectares of integrated planting of *Aquilaria* spp. and banana (*Musa* spp.) the calculated values for NPV and IRR are RM185,583,384 and 54.85% respectively. The B/C ratio is more than one which is 3.30. Whereas for 1,000 hectares planting *Aquilaria* spp. with a single crop has a slightly lower NPV and IRR value of RM153,638,130 and 38.49 % respectively. In-terms of B/C ratio it is slightly higher than integrated planting (Table 8). The present worth of benefits for the project is more than the present worth of cost for both options.

Insert table (8) about here

The financial analysis carried out in this study indicates that for both options the selected species with integrated and single planting have potential and could provide a consistent return to the planters, as the analysis shows a positive NPV, quite high in IRR and B/C ratio is more than one.

Sensitivity analysis

To test the project's viability with respect to changes in price and cost, a sensitivity analysis is carried out. In this study, variation of sensitivity are based on positive increases for costs of 5%,10%, 15%, 30% and 40% and negative decreases for price of 5%, 10%, 15%, 30% and 40%. The analysis indicates that the project is still financially viable (referring to the integration planting) even with a 40% increase in cost but with the decreasing of price at more than 58% (Table 9), the project would be operated at a loss with the cost remains unchanged. In-terms of yield volume and price, if actual yield volume achieved is only 500 gram/tree for agarwood and 14 kg/tree for banana (50% drop in yield), the project is viable only if the price is at RM850/kg agarwood and RM0.76/kg banana and above (Table 10). At the assumed estimated price of RM1,000/kg of agarwood and RM0.90/kg of banana, the range from a lower yield volume of between 500 gram agarwood and 14 kg banana per tree to a higher yield of 900 gram agarwood and 25.2 kg banana per tree, the IRR could improve from 16.73 to 46.18%. Considering the price remains unchanged, the project would be operated at a loss if the yield volume achieved drops more than 58%.

Insert table (9) about here

Insert table (10) about here

In the case of planting *Aquilaria* spp. as a single crop for agarwood production, the sensitivity analysis indicates that the project is still financially viable even with a 40% increase in cost but with the decreasing of price at more than 66% (Table 11), the project would be operated at a loss with the cost remains unchanged. In-terms of yield volume and price, if actual yield volume achieved is only 500 gram/tree (50% drop in yield), the project is viable only if the price is at RM683/kg and above. At the assumed estimated price of RM1,000/kg, at higher yield volume of between 500 gram to 900 gram per tree, the IRR could improve to between 20.29 to 35.73% (Table 12). Considering the price remain unchanged, the project would be operated at loss if the yield volume achieved falls more than 65%.

Insert table (11) about here

Insert table (12) about here

Conclusions

Both options, whether planting *Aquilaria* spp. integration with banana (*Musa* spp.) or planting *Aqualaria* spp. as a single crop for agarwood production are viable. An investment return for planting *Aqualaria* spp. integrated with banana (*Musa* spp.) is much higher with an IRR of 54.85% compared with 38.49% for a single crop plantation. The NPVs of investment at 10% discount for a 1,000 hectares integrated planting are RM185.6 million while the option involving single crop plantation for agarwood production is RM153.6 million. The better present value of return of the option involving integration planting is attributed to the added and earlier revenue contribution from agriculture crop. The good demand and encouraging banana price over the years would make this option the preferred choice. However, the establishment of *Aqualaria* spp. plantation solely for agarwood production also has its attraction. The option is not labour intensive. This speaks well for a rapidly developing country like Malaysia, where labour is no more a luxury relative to neighboring countries.

References

Barden A., Noorainie, A. A., Mulliken, T., and Song, M. (2002) Heart of the Matter: Agarwood Use and Trade and CITES Implementation for *Aqualaria malaccencis.* Traffic Network Report.

Burkill, I.H. (1966) A Dictionary of the Economic Products of the Malay Peninsula.

Chang, Y.S., Nor Azah, M. A. and Abu Said, A. (2001) Gaharu: a prized incense from Malaysia. *Malaysian Oil Science and Technology* 9 (2): 26-27.

Chang Y.S., Nor Azah, M.A., Abu Said, A., Lok, E.H., Reader, S. and Spiers, A. (2002) Gaharu. FRIM Technical Information No. 69.

Donovan, D.R. & Puri, P.K. (2004). "Learning from traditional knowledge of non-timber forest products: Penan Benalui and the Autecology of *Aquilarai* in Indonesian Borneo". Ecology and Society (9):3. [Online] URL:http://www.ecologyandsociety.org/vol9/iss3/art3.

Gimlett, J.D. (1930) The medical book of Malayan medicine. *The Gardens Bulletin, Straits Settlements* 4(3): 333-497.

Najib Lotfy, A., Ahmad Fauzi, P. & Mahmud A. W. 1999. *Agroforestry for Forest Plantation in Malaysia*, Paper Presented at the Seminar on Forest Plantation: Towards Greater Efficiency and Productivity, 6 November 1999, Auditorium Tawau Library, Tawau, Sabah.

Nik Hassan Shuhaimi, N.A.R. 1998 "Early History", The Encyclopaedia of Malaysia, Volume 4.

Normala Ashikin, A.W. 2008. Panduan Menanam Pisang. Jabatan Pertanian Malaysia

Zich, F. & Compton, J. 2002 The Final Frontier: Towards Sustainable Management of Papua New Guinea's Agarwood Resource. A TRAFFIC Oceania Report in conjunction with WWF South Pacific Programme.

Table 1. Uses of Agarwood

	Use	**Remark**
Production of Incense	Homes, religious ceremonies, rituals and meditation	Most prized of all incense
Oud (Arabic word for wood)	Symbol of status, wealth and hospitality in Middle East	-
Gaharu chips	homes in Middle East	-
Gaharu oil	in perfume and toiletry products such as soap & shampoo	-
Wood	Ayurvedic, Chinese and other Asian traditional Asian medicine	
Wood	sculptures, beads & boxes	Religious purpose

Source: Chang *et al*. 2002 and Barden *et al*. 2000

.

Table 2.Capital expenditure in establishing 1,000 hectares integrated (*Aquilaria* spp. and Banana) plantation

Items	7 years
Capital Expenditure	
For Agarwood	
a) Land preparation costs	
- Felling & land clearing (RM4,940/ha)	4,940,000.00
b) Planting costs (lining and holing)@RM2/tree	1,482,000.00
c) Seedling costs + transportation	
- RM 7.00 (RM5,831/ha)	5,831,000.00
d) Site dressing	
Christmas Islands Rock Phosphate	
(CIRP)@100g/seedling@RM10.00/kg	833,000.00
e) Transportation and Equipment	
- Generator set, pick-up 4X4, Motorbike,	
Truck 'small lories', car and sprayer	316,000.00
f) Building and Amenities Cost	
- Initial set up and office (site office), storage shed, Office equipment and furniture, Water tank and treatment ,	
Utility and parking	355,000.00
g) Road system (RM/ha)	
- a major road (49m/ha, RM8/m)	392,000.00
- Secondary road (74m/ha, RM4/m)	296,000.00
h) Culvert and drainage (RM299/ha)	299,000.00
i) Field water tank (RM247/ha)	247,000.00
For Banana(additional)	
a) Planting costs (lining, holing &	
planting)@RM3/tree @RM3,297/ha	3,297,000.00
b) Seedling costs including transportation	
@ RM3 x 1099 (RM3,297/ha)	3,297,000.00
c) Site dressing	
- (CIRP) @ 100g/seedling@RM10/kg	1,099,000.00
- Ground Magnesium Limestone (GML) @	
100g/seedling@RM2/kg	220,000.00
- Bio-organic @ 100g/seedling@RM2/kg	220,000.00
d) Drainage system @ RM988/ha	988,000.00
e) Irrigation system @ RM247/ha)	247,000.00
f) Transportation and Equipment (additional)	
- Sprayer, Generator for coldroom , Forklift , Motorbike,	
Trucks and Farm equipment	392,000.00
g) Building and Amenities Cost	
- Warehouse, 25 units quarters, Coldroom, Canteen set up,	
Utility & parking	1,560,000.00
h) Electricity/transformer	500,000.00
i) Water tank and treatment	35,000.00

Table 3. General charges and operating costs for 1,000 hectares of integrated (*Aquilaria* spp. and Banana) plantation

Items	7 years
General charges & Operating costs	
For Agarwood	
a) Wages & salaries	
- 1 Chairman (RM10,000.00/month)	120,000.00
- 1 Deputy Chairman (RM8,000.00/month)	96,000.00
- 1 Managing Director (RM15,000.00/month)	180,000.00
- 1 Executive Director (RM12,000.00/month)	144,000.00
- 1 Directors (RM5,000.00/month)	60,000.00
- 1 Plantation head (RM12,000.00/month)	144,000.00
- 1 Plantation Manager (RM6,000.00/month)	72,000.00
- 1 Supervisor (RM2800/month)	33,600.00
- 15 General workers (RM1,100.00/month)	198,000.00
* Assuming 8% annual increase in salary	
Region Office	
- 3 Staffs (RM2,000.00/month)	72,000.00
- 1 Driver (RM1,500.00/month)	18,000.00
* Assuming 6% annual increase in salary	
- Bill @ RM1,500.00/month	18,000.00
b) EPF/SOCSO @12%/year (total RM for 7 years)	1,452,027.31
c) Group general insurance premium (RM500.00/month)	6,000.00
d) Medical (RM1,000.00/month)	12,000.00
e)Utility	
-Electricity @ RM1,000/month (RM/year)	12,000.00
-Water consumption (RM/year)	3,600.00
f) Office rental – Region office @ RM2,000.00/month	24,000.00
g) Extraction cost @RM19,982/ha (felling and extraction of agarwood rasin)	19,982,000.00
h) Innoculation costs, once every five years @ RM50x833 trees	41,650,000.00
l) Interest fee @ 7%/year - figure based on integration planting	1,892,100.00
If single crop (agarwood only), interest fees reduced to RM1,062,250 per year	
For Banana (additional)	
a) Utility	
-Electricity (RM/year)	
- electric power installed 25Kw, assumed a service load factor of 90% of installed power, average consumption at 22.5Kw. Assuming cooling activity operate 24 hours for about 60 days per cycle. Electricity rate RM0.29/kWh	18,792.00
-Water consumption (RM/year)	3,600.00
b) Wages & salaries (additional)	
- 2 Supervisors (RM2,800/month)	67,200.00
- 2 Asst. Supervisors (RM1,800.00/month)	43,200.00
- 3 Staffs (RM1200/month)	43,200.00
* Assuming 8% annual increase in salary	
c) EPF/SOCSO @12%/year (total RM for 4 years)	83,056.66
d) Contract work inclusive weeding, pruning and harvesting labour @ 500 workers, RM35/day (RM/year)	5,040,000.00
e) Medical @ RM1000/month (RM/year)	12,000.00

Table 4. Cost of maintenance for 1,000 hectares of integrated (*Aquilaria* spp. and Banana) plantation

Items	7 years
Maintenance cost	
For Agarwood	
a) Weeding - input	
year 1 – 4 @RM74/ha/year (RM/year)	74,000.00
b) Pest & disease control - input	
year 1-4 @RM74/ha/year (RM/year)	74,000.00
c) Road & bridge maintenance @RM69/ha	
- Every 3 year	69,000.00
d) Fertilizer (applied for 4 years)	
- (100g/tree x 833 tree)@83kg/ha,@ 2 times/year, RM2/kg (RM332/ha)	332,000.00
e) Drainage maintenance @RM99/ha	
- Every 3 years	99,000.00
f) Irrigation maintenance @RM59/ha	
- Every 3 years	59,000.00
g) Maintenance of vehicle (RM/year)	8,000.00
h) Petrol (lorry, car, pick-up & motorbike) (RM/yrs)	14,000.00
For Banana (additional)	
a) Fertilizer (applied for 3 years)	
- NPK 15:15:15@960g/tree/yr@RM3/kg (RM3,165/ha)	3,165,000.00
- Bio-organic@75g/tree, applied for 6 time, RM2/kg (RM989/ha)	
b) Weeding – input	989,000.00
year 1 – 4 @RM74/ha/year (RM/year)	
c) Pest control – input	74,000.00
year 1-4 @RM200/ha/year (RM/year)	
d) Disease control	200,000.00
year 1-4 @ 3kg/ha @RM240/ha/year (RM/year)	
e)Canteen maintenance (RM6000/year)	240,000.00
	6,000.00

Table 5. A summary of cash outflows for the plantation with a 7-year project rotation

Item/Option	Capital expenditure (RM)	Maintenance cost (RM)	Admin. & other operational cost (RM)	Contingency cost (RM)	Total cash outflow (RM)
Option 1 Integrated croping - Set up 1,000 ha plantation for agarwood and banana production	27,030,000	21,786,400	118,115,518	16,693,192	183,625,110
Option 2 Set up 1,000 ha plantation for agarwood production only	15,175,000	2,528,000	91,233,805	10,893,680	119,830,485

Table 6. Other contribution costs for 1,000 ha of Integrated (*Aquilaria* spp. and Banana) plantation

Items	7 years
Other Contribution Costs	
a) Authorities costs	
- Land lease to government authority (RM4,940/ha)	4,940,000.00
- Land permit and deposits for 1,000 ha (Forestry/Plantation Department)	2,025,000.00
- Royalty	750,000.00
b) Social contribution @ RM3,500/month (RM/year)	42,000.00

Table 7. Summary of net cash flow for a 1,000 ha plantation with a 7-year project rotation

	Total cost/outflow	Total revenues	Net cash flow
Option 1 Integrated croping - Set up 1,000 ha plantation for agarwood and banana production	RM183,625,110	RM605,235,200	RM421,610,090
Option 2 Set up 1,000 ha plantation for agarwood production only	RM119,830,485	RM500,000,000	RM380,169,515

Table 8. NPV, IRR and B/C ratio of 1,000 hectares plantation with 7-year project rotations

	NPV discounted @ 10%	*IRR (%)*	*B/C ratio*
Option 1 Integrated croping - Set up 1,000 ha plantation for agarwood and banana production	185,583,384	54.85	> 1 (3.30)
Option 2 Set up 1,000 ha plantation for agarwood production only	153,638,130	38.49	> 1 (4.17)

Table 9. Sensitivity analysis of 1,000 hectares of integration of two species (*Aquilaria* spp. and *Musa* spp.) on plantation

Item (Changes in Cost and Price)	Net Present Value (NPV)	Internal Rate of Return (IRR)	Benefit/cost Ratio (B/C)
Increase cost by 40%	RM133,157,119	32.15%	2.35
Increase cost by 30%	RM146,263,685	36.13%	2.54
Increase cost by 15%	RM165,923,534	43.74%	2.87
Increase cost by 10%	RM172,476,818	46.92%	3.00
Increase cost by 5%	RM179,030,101	50.58%	3.14
Increased price by 15%	RM233,080,741	70.98%	3.79
Increased price by 10%	RM217,248,288	65.03%	3.63
Increased price by 5%	RM201,415,836	59.70%	3.46
No changes	RM185,583,384	54.85%	3.30
Decreased price by 5%	RM169,750,932	50.37%	3.13
Decreased price by 10%	RM153,918,479	46.18%	2.97
Decreased price by 15%	RM138,086,027	42.21%	2.80
Decreased price by 30%	RM90,588,670	31.13%	2.31
Decreased price by 40%	RM58,923,765	24.01%	1.98
Decreased in price > 58%	Not viable		
Decreased cost by 5%	RM192,136,667	59.97%	3.47
Decreased cost by 10%	RM198,689,950	66.30%	3.66
Decreased cost by 15%	RM205,243,233	74.44%	3.88

Table 10. IRR at different yields volume and prices

Volume Yield/tree	Price (RM/kg)											
	Agarwood	Banana	Agarwood	Banana	Agarwood	Banana	Agarwood	Banana	Agarwood	Banana	Agarwood	Banana
	1000	0.90	900	0.81	850	0.76	800	0.72	750	0.67	700	0.63
	No change		10% decreased		15% decreased		20% decreased		25% decreased		30% decreased	
> 58% drop	Not viable		Not viable		Not viable		Not viable		Not viable		Not viable	
50% drop Agarwood - 500 g Banana - 14 kg	16.73%		12.89%		10.84%		Not viable		Not viable		Not viable	
40% drop Agarwood - 600 g Banana - 16.8 kg	24.01%		29.68%		17.39%		15.21%		12.82%		10.50%	
30% drop Agarwood - 700 g Banana - 19.6 kg	31.13%		26.15%		23.54%		21.14%		18.48%		15.97%	
20% drop Agarwood - 800 g Banana - 22.4 kg	38.41%		32.56%		29.55%		26.86%		23.88%		21.14%	
10% drop Agarwood - 900 g Banana - 25.2 kg	46.18%		39.16%		35.63%		32.56%		29.18%		26.15%	

Table 11: Sensitivity analysis of a 1,000 hectres of *Aquilaria* spp. on plantation for agarwood production only

Item (Changes in Cost and Price)	Net Present Value (NPV)	Internal Rate of Return (IRR)	Benefit/cost Ratio (B/C)
Increase cost by 40%	RM121,791,905	29.68%	2.98
Increase cost by 30%	RM129,753,461	31.62%	3.21
Increase cost by 15%	RM141,695,796	34.83%	3.63
Increase cost by 10%	RM145,676,574	35.99%	3.79
Increase cost by 5%	RM149,657,352	37.21%	3.97
Increased price by 15%	RM188,626,183	42.16%	4.80
Increased price by 10%	RM176,963,499	40.99%	4.59
Increased price by 5%	RM165,300,814	39.77%	4.38
No changes	RM153,638,130	38.49%	4.17
Decreased price by 5%	RM141,975,445	37.14%	3.96
Decreased price by 10%	RM130,312,761	35.73%	3.76
Decreased price by 15%	RM118,650,076	34.23%	3.55
Decreased price by 30%	RM83,662,023	29.15%	2.92
Decreased price by 40%	RM60,336,654	25.10%	2.50
Decreased in price > 66%	Not viable		
Decreased cost by 5%	RM157,618,908	39.83%	4.39
Decreased cost by 10%	RM161,599,686	41.25%	4.64
Decreased cost by 15%	RM165,580,464	42.76%	4.91

Table 12. IRR at different yields volume and prices

Volume Yield/tree	Agarwood price (RM/kg)					
	1000 (No change)	900 (10% decreased)	850 (15% decreased)	800 (20% decreased)	750 (25% decreased)	700 (30% decreased)
> 65% drop	Not viable	Not viable	Not viable	Not viable	Not viable	Not viable
50% drop Agarwood - 500 g	20.29%	17.48%	15.95%	14.32%	12.57%	10.69%
40% drop Agarwood - 600 g	25.10%	22.33%	20.82%	19.21%	17.48%	15.64%
30% drop Agarwood - 700 g	29.15%	26.39%	24.88%	23.29%	21.58%	19.75%
20% drop Agarwood - 800 g	32.65%	29.89%	28.39%	26.80%	25.10%	23.29%
10% drop Agarwood - 900 g	35.73%	32.97%	31.48%	29.89%	28.20%	26.39%