Chapter 3
Research Methodology

3.1 Conceptual Framework

3.1.1 Forests as Capital

The fundamental concept of this study is that capital is any store of wealth, which yields satisfaction to its owner. Via this broad definition capital assets can be classified into three types: Durable goods, Financial assets, and Land and natural resources. All three types of capital assets can be evaluated in similar ways and share some of the same characteristics. For example, all three types can be bought and sold. Furthermore, the buyer of a capital asset expects that the value of the asset will increase over time, thereby providing a profit upon its sale (Klemperer 1996). The value gained over time on a capital asset is known as the rate of return and is the driving force behind the buying and selling of these assets.

However, investments in capital assets are not all the same. Instead, investments vary according to their rates of return and associated levels of risk; liquidity or marketability; maturity, i.e. the length of time the asset must be held before a profit is realized; type of income (capital gain or ordinary) desired for tax purposes; amount of time which must be devoted to managing the investment; and possible protection from inflation or deflation (Mills 1988). Because a potential buyer / investor wants to maximize the rate of return on the money he spends to purchase a capital asset, he must thoroughly consider these attributes before deciding whether or not to invest his money. By investing in a capital asset, which has the same level of risk and maturity but a lower rate of return than another asset, the investor loses the opportunity to gain a higher rate of return some where else.

Under the broad definition of capital given above, forests and tree plantations are considered capital assets. Generally, the returns from forest and tree plantation investments derive only from timber production and can be broken down into three components, which lead directly to monetary gains. First, the biological growth of trees represents an increase in the volume of timber available. Per unit value of timber, the second component, increases with the size of the trees. Trees with different diameters have different end uses and demand different stumpage prices.

For example, smaller trees sold for use as poling or fence posts normally demand a lower price than large diameter trees sold for use in furniture manufacturing. Finally, the third component is derived from real changes in stumpage prices (Mills 1988). In addition to these three, a less direct component, such as wildlife and environmental protection, could be added, but generally is not due to the difficulty in assessing the monetary gain to the plantation owner. Investments in strictly timber producing tree plantations or forests can best be compared with investments in financial bonds as both types of investments require an initial investment of capital and maturity period before providing a one time return.

However, investment returns from neem tree farming (Sadao Thai plantation) vary from that of the traditional timber production plantation in that the Sadao Thai plantation in addition to realizing returns from timber sales also provide annual returns from neem seed sales of as well. In a similar fashion, investments in Sadao Tawai plantations show short-term returns from yearly flower production and long term returns from wood sales. As such, both are much more suited for comparison with common stocks that provide a yearly dividend on top of increases of stock value.

Nonetheless, neem tree farming, like all other types of asset investments, must compete for investment capital. As a result of this, investments in both types of small scale neem tree farming must show investment worthiness, or otherwise lose out on available investment capital.

3.1.2 Purpose of Each Type of Neem (Sadao) Tree

Sadao Thai: The Sadao Thai variety of the Thai neem tree is used primarily for seed and timber production. Flowers can be collected for sale, but this precludes seed production. In addition, Sadao Thai flowers are more bitter than those of the Sadao Tawai variety and therefore demand a lower price. Although seed production is a major goal of plantation establishment, Sadao Thai plantations do not resemble fruit orchards, but appear as any other type of timber production.

Sadao Tawai: The Sadao Tawai variety of the Thai neem tree is used for flower and fuel wood production. The flowers are the primary product while fuel wood is a by-product. The Nature of Sadao Thai flower production resembles that of fruit production rather that of timber production.

3.2 Analytical Methodology

3.2.1 Descriptive Method:

The descriptive method will be used to describe the financial and economic potential of the neem tree by discussing the different parts of the neem tree that can be used for economic purposes and the various domestic and international markets for neem based products. The descriptive method will also be employed in the analysis of the Thai timber and insecticide markets. Moreover, the effects of neem tree farming on the Thai economy will also be examined using the descriptive analysis.

3.2.2 Quantitative Method:

The quantitative method of data analysis will be used in order to analyze the financial feasibility of a neem tree plantation investment based on a one rai plot of land by predicting the Net Present Value (NPV), Benefit-Cost Ratio (B/C), and Internal Rate of Return (IRR) of the project at varying values of interest, price per cubic meter of lumber, and price per kilogram of neem seed.

3.2.2.1 Measurement of Investment Worthiness

3.2.2.1.1 Net Present Value (NPV)

The net present value of an investment project is the present value of all revenues minus the present value of all costs. It defines an investor's maximum willingness to pay for an asset based on estimated revenues (benefits), costs, and a desired rate of return. The NPV is defined mathematically by the following equation:

$$NPV = B_0 + \frac{B_1}{(1+r)^1} + \frac{B_2}{(1+r)^2} + \cdots + \frac{B_t}{(1+r)^t} - C_0 - \frac{C_1}{(1+r)^1} - \frac{C_2}{(1+r)^2} - \cdots - \frac{C_t}{(1+r)^t}$$

or

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

where B_t = revenue in year t

C_t = cost in year t

r = real interest rate, percent/100

t = an index for years (0, 1, 2, 3, ..., n)

The NPV criterion for investment states that a project is acceptable if the NPV is zero or greater. The present value of revenues must be greater than or equal to the present value of costs, both of which must be computed using the investor's minimum acceptable rate or return (MAR).

$$PV_{revenue} \geq PV_{cost}$$

$$NPV \geq 0$$

When using the NPV's of several projects to decide which project to choose, projects with the highest NPV should be chosen first.

3.2.2.1.2 Internal Rate of Return (IRR)

The internal rate of return of a project is the discount rate at which the present value of revenues minus the present value of costs equals zero (NPV = 0). It shows the rate of return earned on funds invested in a project. Mathematically, this can be expressed as follows:

$$IRR = the \text{ r at which } \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} = 0$$

The IRR investment guideline states that a project is acceptable if its IRR is equal to or greater than the investor's minimum acceptable rate of return (MAR).

$$IRR \geq MAR$$

Therefore, projects with an IRR less than the MAR are unacceptable.

3.2.2.1.3 Benefit/Cost Ratio (B/C ratio)

A project's benefit/cost ratio is also called a profitability index and is the present value of benefits (revenues) divided by the present value of costs using the investor's MAR.

$$B/C \text{ ratio } = \frac{PV_{revenues}}{PV_{costs}} = \sum_{t=0}^{n} \frac{B_t}{(1+r)^t} \Big/ \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$$

According to the B/C ratio criterion, projects are acceptable when the B/C ratio is 1 or greater and unacceptable if the B/C ratio is less than 1. More simply put, if the B/C ratio ≥ 1 then the project is acceptable, and if the B/C ratio < 1, then it is not.

B/C ratio $\geq$ 1 acceptable
B/C ratio $<$ 1 unacceptable

3.2.2.2 Sensitivity Analysis.

A sensitivity analysis is a numerical examination that tests how sensitive a financial outcome of a investment project is to changes in selected variables. Generally, investment profitability is more sensitive to changes in some variables than others. Sensitivity analyses are conducted by first calculating the investment profitability criterion (here NPV, IRR and B/C ratio) for the investment's most probable scenario, and then testing how the criterion values change as selected variables are varied from their most likely values to low and high levels. By conducting a series of sensitivity analyses, investment uncertainty and risks can be identified and risk management plans can be devised to cope with various investment uncertainties (Klemperer 1996).

The variables of concern for the sensitivity analysis in this study are as follows:

1. Inclusion of government afforestation subsidy for Sadao Thai investments
2. Minimal Acceptable Rates of return (MAR): 10%, 12%, 15%, and 20%.
3. Neem seed price per kilogram: 5, 10, and 15 Baht.
4. Neem flower price per kilogram: 50, 80, and 100 Baht.
5. Stumpage price per cubic meter for the Sadao Thai final cut: 1,000; 5,000; and 10,000 Baht.
6. Stumpage price per tree for the Sadao Tawai clear-cut: 200 and 300 Baht.
7. Shorter investment periods of 15, 20, and 30 years.
8. Inclusion of 50,000 Baht per Rai land price.
9. Inclusion of opportunity costs of 1,000, 2,000, 3,000, 4,000, and 5,000 Baht.
10. Price per tree for the Sadao Thai commercial thinning 50, 80, and 175 Baht.
11. 25% and 50% Decreases in the estimated Sadao Thai growth rate.
12. Inclusion of 10% inflation hedge.

3.3 Empirical Models used in this Study.

3.3.1 Production Model #1A: Sadao Thai Plantation with Government Subsidy, Spacing 4 X 2.

3.3.1.1 Benefits (Income Stream):

1. Government Subsidy Income (Years 1 - 5)

$$B^{GS} = \sum_{t=1}^{5} B_t^{GS} = B_1^{GS} + \frac{B_2^{GS}}{(1+r)^1} + \frac{B_3^{GS}}{(1+r)^2} + \frac{B_4^{GS}}{(1+r)^3} + \frac{B_5^{GS}}{(1+r)^4}$$

Where

B_t^{GS} = Revenue from government subsidies in years 1 through 5.
t = An index for years (1, 2, 3, 4, and 5).

2. Seed Production (Income from seed sales in Years 5 - 40)

$$B^{SP} = \sum_{t=5}^{40} B_t^{SP} = \frac{B_5^{SP}}{(1+r)^4} + \frac{B_6^{SP}}{(1+r)^5} + \frac{B_7^{SP}}{(1+r)^6} + \cdots + \frac{B_{40}^{SP}}{(1+r)^{39}}$$

Where

B_t^{SP} = Revenue from seed production in years 5 through 40.
t = An index for years (5, 6, 7, ..., 40).

3. Timber Production (Income from commercial thinnings in Years 5 and 10, and clear cut sales in Year 40)

$$B^{TP} = \frac{B_5^{TP}}{(1+r)^4} + \frac{B_{10}^{TP}}{(1+r)^9} + \frac{B_{40}^{TP}}{(1+r)^{39}}$$

Where

B^{TP} = Revenue from timber production in years 5, 10, and 40.

3.3.1.2 Costs (Expense Stream):

1. Site Preparation Costs: initial investment cost in year 1

$$C^{SP} = C_1^{SP}$$

Where

C^{SP} = Costs of site preparation in year 1.

2. Planting Costs: initial investment cost in year 1

$$C^{P} = C_1^{P}$$

Where

C^{P} = Costs of tree planting in year 1.

3. Plantation Maintenance Costs (Years 1 - 40)

$$C^{M} = \sum_{t=1}^{40} C_t^{M} = C_1^{M} + \frac{C_2^{M}}{(1+r)^1} + \frac{C_3^{M}}{(1+r)^2} + \cdots + \frac{C_{40}^{M}}{(1+r)^{39}}$$

Where

C_t^{M} = Costs of plantation maintenance in years 1 through 40.
t = An index for years (1, 2, 3, ..., 40).

4. Seed Collection Costs (Years 5 - 40)

$$C^{SC} = \sum_{t=5}^{40} C_t^{SC} = \frac{C_5^{SC}}{(1+r)^4} + \frac{C_6^{SC}}{(1+r)^5} + \cdots + \frac{C_{40}^{SC}}{(1+r)^{39}}$$

Where

C_t^{SC} = Costs of seed collection in years 5 through 40.
t = An index for years (5, 6, 7, ..., 40).

5. Thinning Costs (Years 5 and 10) and Clear Cut Costs (Year 40)

$$C^{TP} = \frac{C_5^{TP}}{(1+r)^4} + \frac{C_{10}^{TP}}{(1+r)^9} + \frac{C_{40}^{TP}}{(1+r)^{39}}$$

Where

C^{TP} = Costs of commercial thinnings in year 5 and 10 and cost of clear cut in year 40.

By using the above equations, the NPV, IRR, and B/C ratio can be expressed as follows:

$$NPV^{GS}_{\text{Sadao Thai Plantation}} = \left(B^{GS} + B^{SP} + B^{TP}\right) - \left(C^{SP} + C^{P} + C^{M} + C^{SC} + C^{TP}\right)$$

$$IRR^{GS}_{\text{Sadao Thai Plantation}} = \text{ r at which } \left[\left(B^{GS} + B^{SP} + B^{TP}\right) - \left(C^{SP} + C^{P} + C^{M} + C^{SC} + C^{TP}\right)\right] = 0$$

$$(\text{B/C ratio})^{GS}_{\text{Sadao Thai Plantation}} = \frac{\left(B^{GS} + B^{SP} + B^{TP}\right)}{\left(C^{SP} + C^{P} + C^{M} + C^{SC} + C^{TP}\right)}$$

Where

$NPV^{GS}_{\text{Sadao Thai Plantation}}$ = Net Present Value of a Sadao Thai Plantation including government subsidies.

$IRR^{GS}_{\text{Sadao Thai Plantation}}$ = Internal Rate of Return of a Sadao Thai Plantation including government subsidies.

$(\text{B/C ratio})^{GS}_{\text{Sadao Thai Plantation}}$ = Benefit / Cost ratio of a Sadao Thai Plantation including government subsidies.

r = Discount rate.

3.3.2 Production Model #1B: Sadao Thai Plantation without Government Subsidy, Spacing 4 X 2.

Production model #1B is the same as that for production model #1A except that the benefits from government forestry promotion subsidies are not included. All costs remain the same between these two models.

The NPV, IRR, and B/C ratio formulas for this production model are expressed as follows:

$$NPV_{\text{Sadao Thai Plantation}} = \left(B^{SP} + B^{TP}\right) - \left(C^{SP} + C^{P} + C^{M} + C^{SC} + C^{TP}\right)$$

$$IRR_{\text{Sadao Thai Plantation}} = \text{ r at which } \left[\left(B^{SP} + B^{TP}\right) - \left(C^{SP} + C^{P} + C^{M} + C^{SC} + C^{TP}\right)\right] = 0$$

$$(\text{B/C ratio})_{\text{Sadao Thai Plantation}} = \frac{\left(B^{SP} + B^{TP}\right)}{\left(C^{SP} + C^{P} + C^{M} + C^{SC} + C^{TP}\right)}$$

Where

$NPV_{\text{Sadao Thai Plantation}}$ = Net Present Value of a Sadao Thai Plantation.
$IRR_{\text{Sadao Thai Plantation}}$ = Internal Rate of Return of a Sadao Thai Plantation.
$(B/C\ ratio)_{\text{Sadao Thai Plantation}}$ = Benefit / Cost ratio of a Sadao Thai Plantation.
r = Discount rate.

3.3.3 Production Model #2: Sadao Tawai Plantation, Spacing 6 X 6

3.3.3.1 Benefits (Income Stream):

1. Flower Production (Income from flower sales in Years 2 - 40)

$$B^{FP} = \sum_{t=2}^{40} B_t^{FP} = \frac{B_2^{FP}}{(1+r)^1} + \frac{B_3^{FP}}{(1+r)^2} + \frac{B_4^{FP}}{(1+r)^3} + \cdots + \frac{B_{40}^{FP}}{(1+r)^{39}}$$

Where

B_t^{FP} = Revenue from flower production in years 2 through 40.
t = An index for years (2, 3, 4, ..., 40).

2. Wood Production (Income from sale of wood for charcoal or wood chip use in Year 40)

$$B^{WP} = \frac{B_{40}^{WP}}{(1+r)^{39}}$$

Where

B^{WP} = Revenue from wood production in year 40.

3.3.3.2 Costs (Expense Stream)

1. Site Preparation Costs: initial investments cost in year 1

$$C^{SP} = C_1^{SP}$$

Where

C^{SP} = Costs of site preparation in year 1.

2. Planting Costs: initial investment cost in year 1

$$C^{P} = C_1^{P}$$

Where

C^{P} = Costs of tree planting in year 1.

3. Plantation Maintenance Costs (Years 1 - 40)

$$C^{M}=\sum_{t=1}^{40}C_{t}^{M}=C_{1}^{M}+\frac{C_{2}^{M}}{(1+r)^{1}}+\frac{C_{3}^{M}}{(1+r)^{2}}+\cdots+\frac{C_{40}^{M}}{(1+r)^{39}}$$

Where

C_t^M = Costs of plantation maintenance in years 0 through 40.
t = An index for years (1, 2, 3, ..., 40).

4. Flower Collection Costs (Years 2 - 40)

$$C^{FC}=\sum_{t=2}^{40}C_{t}^{FC}=\frac{C_{2}^{FC}}{(1+r)^{1}}+\frac{C_{3}^{FC}}{(1+r)^{2}}+\cdots+\frac{C_{40}^{FC}}{(1+r)^{39}}$$

Where

C_t^{FC} = Costs of flower collection in years 2 through 40.
t = An index for years (2, 3, 4, ..., 40).

5. Clear Cut Costs (Year 40)

$$C^{WP}=\frac{C_{40}^{WP}}{(1+r)^{39}}$$

Where

C^{WP} = Costs of plantation clear cut in year 40.

By using the above equations, the NPV, IRR, and B/C ratio equations are expressed as follows:

$$\text{NPV}_{\text{Sadao Tawai Plantation}}=\left(B^{FP}+B^{WP}\right)-\left(C^{SP}+C^{P}+C^{M}+C^{FC}+C^{WP}\right)$$

$$\text{IRR}_{\text{Sadao Tawai Plantation}}=\text{ r at which }\left[\left(B^{FP}+B^{WP}\right)-\left(C^{SP}+C^{P}+C^{M}+C^{FC}+C^{WP}\right)\right]=0$$

$$(\text{B/C ratio})_{\text{Sadao Tawai Plantation}}=\frac{\left(B^{FP}+B^{WP}\right)}{\left(C^{SP}+C^{P}+C^{M}+C^{FC}+C^{WP}\right)}$$

Where

$\text{NPV}_{\text{Sadao Tawai Plantation}}$ = Net Present Value of a Sadao Tawai Plantation.
$\text{IRR}_{\text{Sadao Tawai Plantation}}$ = Internal Rate of Return of a Sadao Tawai Plantation.
$(\text{B/C ratio})_{\text{Sadao Tawai Plantation}}$ = Benefit / Cost ratio of a Sadao Tawai Plantation.
r = Discount rate.

3.4 Description of Capital Costs and Benefits from two types of Thai neem tree plantation.

3.4.1 Sadao Thai Plantation, tree spacing 4 X 2.

3.4.1.1 Benefits:

3.4.1.1.1 Quantifiable Benefits:

1. Revenue from the sale of collected neem seeds from years 5 to 40.

The sale of neem seeds collected from planted neem trees makes up a major component of the benefits of a neem plantation investment. Presently, neem seeds are bought and sold in the Thai market in three different types with each type having its own price. The first type comes in the form of ripe fruit which buyers purchase at a low price of approximately 3 Baht/Kg and then separate the endocarp (fruit pulp) from the seeds themselves. Demanding the highest price of approximately 25 Baht/Kg, cleaned seeds, the second type, are seeds which the farmers have already removed the endocarp and dried. Dried fruit, the third type, are seeds that have not had the endocarp removed. Once the endocarp dries to the seed, it becomes very sticky and is extremely difficult to remove. Dried fruit prices presently range from 5 to 10 Baht/Kg. Both ripe fruit and cleaned seeds are more labor intensive than dried fruit, because the farmer must make several trips per week to the plantation in order to collect the ripe fruit before the endocarp (fruit pulp) dries to the seed. In the case of cleaned seeds, the farmer must expend much more labor or invest in a de-pulping machine to clean off the endocarp. However, dried fruit are much easier to collect, because the farmer only has to gather the seeds that have fallen to ground and dried naturally. And since the farmer is not rushed to remove the endocarp, he need only to collect the dried fruit once a week.

Because the neem insecticide companies contacted reported buying primarily dried fruit, the financial analysis of neem seed production only considered the benefits (cash inflows) from the sale of dried fruit.

The Thai neem tree starts producing small amounts of fruit as early as the second year, however doesn't start producing harvestable amounts until the fifth year. There has been very little data published on the fruit production cycles of the neem tree in general, and absolutely no data has been published specifically on the fruit production cycles of the Thai neem tree in Thailand. Fruit production quantities used in this thesis were attained from personal communications with the Neem Company Ltd., and the Rangsit Agri-Economic Ltd., Part. Company. Mr. Pak Chung, managing director of the Neem Co., conservatively estimates the per tree dry weight, fruit production to be around 5 kg's in year five and 7.4 kg's in year ten and beyond, while Mr. Annop Tansakul of the Rangsit Agri-Economic Co. predicts the dry weight fruit production per tree to be around 6.6 to 10.6 Kg's in year five and approximately 60 Kg's in year ten and beyond. Mr. Tansakul's estimations are much brighter than the more frugal predictions by Mr. Chung, however they have one major consideration, which is that his estimates are based on trees growing wild along the side of the road. Since these trees do not have to compete for nutrients and light as strongly as trees grown in monoculture stand, they are more likely to produce greater yields. However, because no data has been published on the fruit yield of Thai neem trees grown in pure stands and at various spacings, it is difficult to say which of the above amounts closure to a pure stand scenario. Another concern about production quantities regards the fruit producing nature of trees themselves. Both companies expressed that they thought the Thai neem tree might have alternate year fruit baring characteristics, meaning that in one year a tree may produce a large quantity of fruit but in the next year produce little or no fruit at all. Both have observed that some of the roadside trees they have been tracking showed high yield in one year and almost no yield in the next. Nevertheless, they were unable to say whether this was due to being truly alternate baring or whether it was due to environmental factors such as the lack of water. If the trees are truly alternate year bearers, than using the figure of 60 Kg's per year from year 10 on could greatly over estimate the benefits from seed sales.

Taking all of this into account, this study used the quantities found in Table 3.1 in the financial analysis of neem seed production. It is assumed that each tree will produce 5 Kg's of dry fruit in year five and then will increase in 3 kilogram increments every year till year 20. After year 20 it is assumed that the yield remains constant until the end of the investment.

Table 3.1 Dry Fruit Volume Estimates

Year	No. of Trees/Rai	Volume (Kg/Tree)	Volume (Kg/Rai)
5	200	5.0	1,000
6	100	8.0	800
7	100	11.0	1,100
8	100	14.0	1,400
9	100	17.0	1,700
10 - 40	100	20.0	2,000

As already stated above, dried neem fruit are currently being purchased from the farmers at rates of 5 to 10 Baht per Kilogram, and could easily rise to 15 Baht/Kg if the demand for seeds increases. To evaluate the broadest possible potential for Sadao Thai plantations, all three of these prices were considered in the financial analysis. The non-discounted cash in-flows from seed sales are represented in Table 3.2.

Table 3.2 Cash-Inflows from Neem Seed Sales

Year	Volume (Kg/Rai)	Dried Neem Fruit Price		
		5 Baht/Kg	10 Baht/Kg	15 Baht/Kg
5	**1,000**	5,000	10,000	15,000
6	**800**	4,000	8,000	12,000
7	**1,100**	5,500	11,000	16,500
8	**1,400**	7,000	14,000	21,000
9	**1,700**	8,500	17,000	25,000
10 - 40	**2,000**	10,000	20,000	30,000

Note: Cash In-flows given in units of Baht/Rai.

2. Revenue from the sale of timber from commercial thinning in year 5, and from the final clear cut at the end of the 40, 30, 20, or 15 year investment period.

A Sadao Thai plantation will realize revenues in two different periods from the sale of timber. The first revenues will come from the commercial thinning of 100 trees at the end of the fifth year after they have already born fruit. The per tree price for the thinning depends on the size of the tree, which due to different growth rates of the individual trees in the plantation, would not be consistent. Yet, to simplify the estimation of thinning revenues all tree being thinned are considered to fall into the same price bracket. Since at present Thailand doesn't have an established market for neem tree thinnings like it does for Eucalyptus and teak, this study uses the price reported by the Thai Department of Business Economics for imported pine poles. Table 3.3 shows the prices as they relate to the diameter and length of the poles. Neem trees planted with a 4x4 spacing at a neem test plantation established in

Table 3.3 Proxy Thinning Prices

Diameter (cm)	Length (m)	Pole Price (Baht/Pole)
10.00	4.00	50.00
12.50	5.00	80.00
15.00	6.00	175.00

Source: Department of Business Economics (January 1998)

Ratchaburi province by Dr. Pongsak Sahunalu (Faculty of Forestry, Kasetsart University) showed an average DBH (diameter at breast height) of 12.22 centimeters and a total height of 9.05 meters at age five. Trees with planted with a spacing of 6x6 and 8x8 showed DBH's of 12.59 and 13.11, and heights of 8.04 and 8.01 meters respectively (Thoranisorn 1985, and personal communication with Dr. Thoranisorn). It should be noted here that trees in the Ratchaburi plantation were not pruned or fertilized, and thus are assumed will show poorer growth performances than trees which have been fertilized and properly pruned. Therefore, properly cared for trees should achieve at least the 80.00 baht price level and could possibly reach the 175.00 baht price. As such, this study uses the 80.00 Baht price level as the standard for the financial analysis. The other two price levels are considered in the sensitivity analysis.

The second revenue derived from wood production is realized in the last year of the investment with a clear-cut harvest of the remaining 100 trees. Using statistical

Table 3.4 Estimated Timber volume (m^3)

Year	15	20	30	40
Volume Per Tree (m^3)	0.312	0.492	0.862	1.160
Volume Per Rai (m^3)	31.162	49.171	86.190	116.030

Note: Volume per Rai Estimates are Based on Plantation Size of 100 Trees per Rai

methods, the per tree volume (m^3) was estimated for the time periods of 15, 20, 30, and 40 years. These volumes are shown in Table 3.4. Currently, the neem tree is not considered to be a major commercial wood species and it is not widely used for timber even though it has good potential for this. As a result, neither the Royal Forestry Department nor the Forest Industry Organization of Thailand was able to quote a stumpage price, the value of tree still standing in the plantation, for the neem tree. Therefore, three potential prices were chosen for the financial analysis. These were 1,000.00, 5,000.00, and 10,000.00 Baht/m^3.

Table 3.5 Log Prices Used by the Royal Forestry Department to Estimate Export Tariffs in Years 1991 to 1997

	Log Prices (Baht/m^3)				
Length	**Oct. 1991 – Mar. 1992**	**Oct. 1992 – Mar. 1993**	**Oct. 1993 – Mar. 1994**	**Oct. 1994 – Mar. 1995**	**Oct. 1996 – Mar. 1997**
			Round Logs		
8' or Longer	13,500 –16,500	13,500 – 20,300	13,500 – 20,300	17,000 – 23,500	22,000 – 35,000
6' to 8'	11,200 – 12,000	11,200 – 12,000	11,200 – 12,000	14,000 – 17,000	20,000 – 25,000
Shorter than 6'	7,500 – 9,500	7,500 – 9,500	8,000 – 10,500	8,500 – 12,000	15,000 – 20,000
			Square Beams		
10' and Greater[1]	15,000 – 16,000	15,500 – 19,300	15,500 – 19,300	22,000 – 26,000	30,000 – 37,000
6' to 10'[1]	13,500 – 15,000	14,000 – 18,400	14,000 – 18,400	19,000 – 22,000	27,000 – 32,000
6' or Longer[2]	12,000 – 13,000	12,500 – 13,000	13,000 – 14,500	16,000 – 19,000	22,000 – 27,000
Shorter than 6'[3]	11,000 – 11,500	11,000 – 11,500	12,000 – 13,000	15,000 – 18,000	20,000 – 24,000

Source: Statistics Unit, Royal Forestry Department

[1] For Beams 10"x10" or Larger

[2] For Beams 10"x10" or Smaller

[3] For Beams 6"x6" or Larger

These prices were based in part on the figures used by the Statistics Unit of the Royal Forestry Department to estimate the export tariffs for teak logs.

The resulting cash flow-inflows at the various investment lengths and prices are represented in Table 3.6.

Table 3.6 Cash In-Flows from Final Clear Cut at Various Prices

Price (Baht/m^3)	Investment Length (Years)			
	15	20	30	40
1,000.00	31,161.78	49,170.54	86,190.50	116,029.70
5,000.00	155,808.92	245,852.70	430,952.50	580,148.49
10,000.00	311,617.84	491,705.39	861,904.99	1,160,296.98

Note: Cash in-flows are given in terms of Baht/Rai.

3. <u>Income from Thai Government Afforestation Subsidy</u>.

The Royal Thai Forestry Department has implemented a afforestation promotion project designed to encourage farmers to plant forests on their farm lands. The project provides farmers, who apply to the program and plant a minimum of 200 trees per Rai, with a 3,000 Baht per Rai subsidy that is paid out over five years in payments of 800, 700, 600, 500, and 400 Baht. In order to qualify for the program, the farmer must be a Thai citizen, must own or have legal permission to use the land under consideration for afforestation, and must not have already received afforestation subsidies from other programs. In addition to this, three other conditions must be met. First, the land being considered must have a land deed or government documentation giving permission for agricultural use. Second, the farmer must intend to plant at least 2 Rai of forest, but not more than 50 Rai. And third, the farmer must plant only tree species designated by the Royal Thai Forestry Department.

Each year's subsidy payment is also subject to various criteria. The first year's payment is made to the farmer after a forestry official has confirmed that the trees have been properly planted and in the ground for not less than 15 days. Payment of the second year's allotment is made after a forestry official has confirmed that the farmer has weeded and plowed the land around the trees, and has conducted a replacement planting of any trees which did not survive the first year. Payments of the third, fourth, and fifth allotments are conducted after a forestry official has confirmed that the farmer has weeded and plowed around the trees, and has cleared fire breaks by no later than the end of March of that year. Failure on the part of the farmer to meet the various year's criteria could lead to forfeiture of the subsidy payment and/or expulsion from the program (Royal Forestry Pamphlet, 2536).

3.4.1.1.2 Unquantifiable Economic and Environmental Benefits:

1. An increase in soil quality.

Neem trees have the ability to neutralize soil acidity, because their leaves are slightly basic. As the leaves build up on the forest floor and decompose, they neutralize acidic soils over time. In addition to this, the root system of the neem tree has the ability to pump nutrients out of leached, sandy soils and store them in the tree's leaves. In a plantation setting these leaves accumulate and restore nutrients to the top soil as they decompose, thereby improving the soil quality (Radwanski, 1981).

2. Protection from soil erosion.

It is a well known fact that tree roots help to hold the soil around them in place while the tree's canopy acts like a shock absorber protecting the soil beneath it from being blasted away by wind and rain.

3. Water retention.

Both the roots and canopies of trees work together to retain water. The canopy slows the rate at which water is evaporated off the soil, while the roots work to absorb the water up into the tree. Neem plantations located on hills could help to both slow the rate of water run off and prevent against soil erosion.

4. An increase in carbon stocks and a decrease in CO_2 levels in the atmosphere.

It is widely accepted that trees generate carbon stocks by absorbing carbon from CO_2 during photosynthesis. The process of photosynthesis releases oxygen into the atmosphere while at the same time reducing high CO_2 levels, which many people believe causes global warming through the green house effect. Therefore, investing in either a Sadao Thai or Sadao Tawai plantation gives nature the chance to sequester carbon and lower carbon dioxide levels in the atmosphere.

5. Generation of microclimates.

Microclimates are defined as a uniform local climate of a small site or habitat. Neem plantations could help generate micro-climates by reducing the temperature in areas shaded by and adjacent to the trees. The same could possibly be true for the relative humidity. By capturing water and releasing it slowly, the area under the trees and adjacent to them could experience a higher humidity level than in open areas.

6. An increase in domestic timber supply.

As more farmers invest capital into Sadao Thai plantations, more timber will become available from tree thinnings and final clear cuts. If popularized, neem timber could easily follow or supercede the present mango and rubber wood trends.

7. An increase in the use of non-synthetic insecticides.

With the generation of an increased supply of cheap non-synthetic insecticides produced from neem seeds, the demand for non-synthetic insecticides should follow Say's Law and increase as well. A shift away from the use of synthetic insecticides itself could have wide ranging positive effects on the overall economy caused by decreases in insecticide imports, and the improved health's of both farmers and agricultural product consumers from the move away from poisonous synthetic insecticides.

8. Generation of micro-industries.

Micro-industries are simply small local industries. The potential for micro-industry formation from Sadao Thai plantations is relatively good. Examples of some of these are Seed collection and processing businesses, small-scale neem pesticide distilleries, businesses producing neem fertilizer from neem cake, neem honey producing industries, and plantation clearing businesses. Of course, many other types of industries could be generated from the existence of neem plantations. Each of these industries would in turn generate employment opportunities for people living near the plantations helping to reduce unemployment and to stimulate the local economy.

3.4.1.2 ***Capital Costs:***

1. Site Preparation Costs in the First Year of the Project

1.1 Labor Costs associated with clearing scrub and underbrush.

It is an assumption on the part of this study that the land being used for setting up a neem plantation is the land that has been previously used for agriculture, meaning that only small scrub and underbrush must be cleared away if necessary. It is therefore presumed that two people working together can cut down and clear away all unwanted scrub and underbrush in two days, which translates into 4 labor days.

A brief discussion of labor costs needs to given here as capital expense for labor figures heavily into the financial analysis. First, it should be noted that on a small-scale neem plantation, most labor would most likely be provided by the plantation owner and his family, and might not normally be considered as a direct expense. However, the cost of labor must be included in the financial analysis since it represents an opportunity cost for plantation owner and his family, i.e. each member of the family who spends a day (1 labor or man day) working on the plantation forfeits the opportunity to earn a day's wage working at an out side job. Moreover, if at some point the plantation owner must hire labor from out side his family to work on the plantation, the cost of this labor is already figured into the analysis results. Second, the cost of labor is figured in terms of Labor days or Man days. At present, the minimum labor day wage in Chiang Mai is set at 150 baht per day. Accordingly, this was the labor day rate incorporated into the financial analysis of the different neem plantations.

Consequently, the cost of the four labor days needed to clear the planting site totals up to 600 baht.

1.2 Tractor Costs: Hiring tractor to plow and level plantation site.

After the planting site has been cleared of under growth, it needs to be graded level and then plowed to prepare the ground for planting. Mr. Vachira KhoPong, director of the Sadao Tawai Company, gave his expert opinion that it would take two hours to grade and level a one rai plot (personal communication, October 1997). He also related that the present rate for hiring a tractor to grade and level land is 400 baht per hour, and that the rate to plow, disk, or rototill a plot runs at a cost of 350 baht per rai. Hence, to grade and plow one rai of land generates a total cash out-flow of 1,150 baht.

2. Planting Costs in the First Year of the Project

2.1 Seedling Costs.

At a 4x2 tree spacing 200 trees can be planted per rai. The Neem Co. Ltd. charges 3 Baht/tree for six month, old seedlings, which have been grown from seeds gathered from high fruit yielding trees. Due to the fact that some degree of phenotype selection was conducted in the collection of seeds for seedling generation, this price was chosen as the standard price for this study. Seedlings grown from seeds collected at random can be purchased for a cheaper price, but there is no guarantee of whether the tree will shown high seed yields or not. At the 3 Baht/seedling price level, the seedling cost comes to 600 Baht.

2.2 Labor Costs.

2.2.1 Laying-out planting site.

Two people working together can lay out and stake a one rai plot in one day. This translates into two labor days costing the farmer 300 baht.

2.2.2 Digging holes for planting and applying fertilizer.

Digging 200 50x50x50 cm holes and then applying 50 grams of fertilizer to the bottom of each hole is estimated to take two labor days to complete accruing another 300 baht.

2.2.3 Planting, and watering seedlings.

An additional cash out-flow of 300 baht is figured into the analysis for the final two labor days needed to plant and water the seedlings. It should be noted here that watering the seedlings is considered a one time expense. This is due to the fact that the study assumes that the seedlings will be planted at the beginning of the rainy season and will be irrigated via rain.

2.3 Equipment Costs.

2.3.1 Bamboo Stakes (50 cm. long).

Fifty-centimeter long bamboo stakes can be obtained at a price of one Baht per stake. Each of the two hundred trees planted in marked out with one stake. Therefore the farmer must purchase a minimum of 200 stakes, spending 200 Baht in the process.

2.3.2. Shovels and Hoes.

The financial analysis figures in the cost of two shovels and two hoes priced at 130 and 120 baht respectively. The total cost for all four tools sums to 500 baht.

2.3.3. Watering Buckets.

The cost of two buckets, which are used for carrying fertilizer and watering the newly planted seedlings, were also included in the calculations. The recorded market value of each bucket was 60 baht, thus leading to a cash out-flow of 120 baht.

2.4. Fertilizer.

First year fertilizer quantities and cash out-flows are represented in Tables 3.6 and 3.7 respectively.

3. Plantation Maintenance Costs in the First to the 40th Year of the Project

3.1. New seedling replacement of dead seedlings.

3.1.1. Dead Tree Replacement Costs.

Neem tree seedlings are extremely hardy and have shown a strong first year survival rate. Neem trees planted with a 4x4 spacing at a test site set up in Ratchaburi province showed a first year mortality rate of less than one percent (Suwith, 1988). Nevertheless, differing genetic and environmental conditions will surely lead some degree of tree death in the first year. To provide a safe margin for this study, a mortality rate of 10 percent was chosen to estimate the number of trees needed for a replacement planting in the second year. This translates into the replacement of 20 trees. At a cost of 3 Baht per tree, the total cash out flow is 60 Baht.

3.1.2 Labor costs associated with seedling replacement.

Since the plantation layout is already established, the time needed to replant 20 trees is minimal, and assumed to be one man-day. Thus, the cash out flow is 150 Baht.

3.2 Weeding and Fire Protection.

Weeding and clearing firebreaks are extremely important aspects of plantation maintenance. High weeds choke and impede the growth rates of smaller trees during the rainy season, and then become fuel for fires in the dry season. Fire, in turn, can severely damage or kill off the trees. Thus weeds and fire can hinder investment return, therefore it is necessary to weed and clear fire breaks each year. This can be most conveniently accomplished by disking and mowing in between the rows of trees once each year. In Chiang Mai the price for hiring a tractor to disk, rototill, or mow is constant at 350 Baht/Rai. During the first year, the plantation owner only needs to mow the weeds down at the end of the rainy season in September or October. In the years following, the plantation owners needs to disk or rototill in between the rows of trees to clear a fire break and control weeds by early March, and then mow down the weeds at the end of the rainy season. The cash out-flow during each year is as follows: Year 1 equals 350 Baht, and Year 2-40 equals 700 Baht per year.

3.3 Tree pruning.

3.3.1 Labor costs associated with tree pruning.

Tree pruning is an extremely important activity which must be under taken every year during the first five years, and then every three years after that. Pruning insures that the trees develop relatively straight trunks, which are later sold for timber. Left un-pruned, neem trees have the tendency to branch out at any where from two to three meter in height causing the bole (trunk) to have a decreased value. The goal of pruning in the neem plantation is to develop trees that have straight boles up to a height of at least four meters. Once the trees have achieved a bole height of four meter, the crowns are allowed to fully branch out to promote a higher level of seed production.

The best time to prune is during the dry season after the trees have born fruit and before major growth starts taking place at the start of the rainy season. The greater majority of pruning will take place during the first five years while the trees are being trained to grow up straight for later timber harvest. After the fifth year, pruning need be conducted as necessary to clear off low level sucker branches and small dead branches which have failed to fall off by themselves and which could leave dead eyes in the bole. Dead eyes decrease the value of the bole, because when the bole is sawn into lumber, the dead eyes fall out leaving holes.

Only one labor day is required to prune and clear away the trimmed branches in the first year since the trees are still relative small. As more rapid growth takes place during years two through five, one and a half labor days is required to prune and to clear off the prunings. In the remaining years of the investment, only one Labor Day is required, due to the fact that only a minimum amount of new branching will occur below the well-established upper crown. The yearly pruning costs are represented in Table 3.7.

Table 3.7 Sadao Thai Plantation Yearly Pruning Costs

Year	1	2 - 5	8, 11, 14, 17, 20, 23, 26, 29, 32, 35, and 38.
Labor (Days/Rai/Year)	1.0	1.5	1.0
Cost (Baht/Rai/Year)	150.00	225.00	150.00

3.3.2 Equipment costs.

3.3.2.1 Clippers and Lopping shears.

The cost of one pair of hand clippers and one pair of lopping shears, priced at 620 and 380 baht respectively, was figured into the financial analysis as a one time cash out-flow in year one.

3.3.2.2 Long Shank Saw.

Because it most likely will not be used to prune branches above two or three meters until the third or fourth year of the investment, the cost of one long shank saw, priced at 350 baht, was included as a one time cash expenditure in the third year.

3.4 Fertilizing Costs.

3.4.1 Chemical fertilizer costs.

Fertilizer cost estimations were based on the market price per kilogram of NPK 15-15-15. Annual per tree fertilizer quantities used to predict cash out flow followed the amounts specified by Tongchai (1993) in his guidebook for

Table 3.8 Sadao Thai Fertilizing Schedule

Year	Number of Trees/Rai	Fertilizer Kg/Tree/Time	Number of Fertilizings/Year	Total Fertilizer Kg/Tree/Year	Total Fertilizer Kg/Rai/Year
1	200	0.05	1	0.05	10
2 - 5	200	0.15	2	0.30	60
6 - 10	100	0.35	2	0.70	70
11 - 40	100	0.55	2	1.10	110

Source: Tongchai, 1993.

setting up Neem Excelsa plantations. Tongchai makes the distinction in his book between small and large-scale plantations. The figures shown in Table 3.8 are those suggested for small-scale plantations, and represent the highest suggested quantity. The present study holds that proper fertilization is a key factor in insuring that the seed and timber production rates discussed above are reached and maintained.

The predicted yearly cash out-flows from fertilizer expenditures are presented in Table 3.9. The total cash out flow was based on a fertilizer (NPK 15-15-15) price of 10.4 baht per kilogram, which was obtained by finding the per kilogram cost of a 50 kilogram bag of NPK 15-15-15.

Table 3.9 Yearly Sadao Thai Plantation Cash Out-Flows From Fertilizer Expenditures

Year	Number of Trees/Rai	NPK 15-15-15 Kg/Rai/Year	Total Cash Out-Flow† Baht/Rai/Year
1	200	10	104.00
2 - 5	200	60	624.00
6 - 10	100	70	728.00
11 - 40	100	110	1,144.00

† Cash out-flow based on a fertilizer price of 10.4 Baht/Kg.

3.4.2 Labor costs associated with tree fertilizing.

Tongchai (1993) suggests that plantation fertilizing take place twice a year during the months of May and August. This study assumes that it will take one labor day per year (.5 labor days / fertilizing) to fertilize a one rai neem plantation. As such, the corresponding yearly cash out-flow is 150 baht.

3.5 Insecticide Costs

3.5.1 Insecticide costs.

Neem trees are for the most part fairly resistant to most types of insect infestations. However, purple spider mites and scales can cause problems for younger trees. The spider mites attack the surface of the leaves causing them to turn white, while scale insects (Aonidiella orientalis and Parasaissetia nigra) infest new shoots and leaves causing them to dry up (Sombatsiri, Ermel, and Schmutterer 1995). Therefore, it is necessary to use a certain amount of pesticide in the early years of the investment in order to protect the trees from being stunted or killed back by these insects. Once the trees have grown and been pruned to a height over three or four meters, it is much less convenient to spray pesticide. To this end, this study expects that a farmer will use a one kilogram bag of *Savin 85* every year for only the first five years. The recorded cost of a one kilogram bag of *Savin 85* was 210 baht.

3.5.2 Labor costs associated with insecticide application.

Since the Thai neem tree suffers from only a small variety of insect pests, this study estimates that only half a man day will be used each year to apply needed insecticide. This relates to a cash out-flow of 75 baht per year in years one through five.

3.5.3 Equipment costs.

One shoulder carried sprayer must be purchased to spray on the necessary insecticide. The recorded price for a sprayer with a metal tank was 990 baht. In addition to the cost of the sprayer, each year spare parts need to be purchased for the sprayer as well. The spare parts in the form of rubber seals will cost approximately 50 baht per year to replace.

4. Seed Collection Costs in the 5th to the 40th Year of the Project

4.1 Labor costs associated with fruit collection.

As was explained in section 3.4.1.1.1, neem seed collection starts at the end of the fifth year and continues on till the end of the plantation investment. Seeds are gathered up from late April to mid May with the total collection period lasting approximately one month. Since the seeds are collected in the form of dried fruit which have fallen to ground and dried on their own, the only labor required is to lay out (and later pick up) the ground netting used to capture the fruit as they fall to the ground and to collect the dried fruit from the netting. Due to the fact that the fruit is allowed to dry on the ground, seed collection does not need to occur very frequently. Miss Onanong Kongtin, production manager for the Neem Co., Ltd., stated that four collection days spaced out over a four period was sufficient to gather all fallen seeds (personal communication, September 1997). In accordance with this, the present financial analysis figured in five labor days for seed collection, i.e. one day to lay out and collect the ground netting and four days for actual seed collection. Given a wage rate of 150 baht per labor day, the total cash out-flow for seed collection comes to 750 baht per year.

4.2 <u>Material costs</u>.

Based on a 4x2 spaced plantation with 10 rows each containing 20 trees, ten 2x100 meter rolls of 80% green netting are needed to cover the ground under the trees. Each roll priced at 1,300 baht/roll and is presumed to have a ten year usage life. Therefore, in years 5, 15, 25, and 35 the plantation owner will have ground netting expenditures of 13,000 baht.

5. Tree Thinning Costs in the 5th Year of the Project

5.1 <u>Labor costs associated with tree thinning</u>.

At the end of year five after the seed collection has been completed, half of the 200 trees in the neem plantation need to be thinned out to leave a residual tree spacing of 4x4 meters thereby allowing the remaining 100 trees to maintain their high rate of growth and fruit production. If the trees are not thinned out, the competition for food and water will hinder the growth and fruit producing ability of all the trees in the plantation.

Because all of the trees in the plantation have been pruned up straight to a height of four meters, only a minimal amount of labor must be expended to clear off smaller branches and cut off the crowns to form four to five meter long poles. The greater majority of labor used in the thinning process is concerned with felling the trees. In total it should take two people three days, six labor days, to fell, clear, and pile the poles outside of the plantation. Thus, at the end of year five a one time cash out-flow of 900 baht is incurred for thinning out the 100 trees.

5.2 Equipment costs.

Each person working to fell and clear out the 100 trees needs to use a medium size hand saw, which were priced at 270 baht per saw. As such, the total one time equipment expenditure for the commercial thinning comes to 540 baht.

Table 3.10 summarizes for the reader the cash in-flows and out-flows for a Sadao Thai investment with a forty year investment length. Shorter investment periods show the same patterns, but with different final clear cut cash in-flows.

Table 3.10 Forty Year Sadao Thai Normal Investment Analysis Including the Government Afforestation Subsidy and 5,000 Baht Opportunity Cost

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Benefits:															
Commercial Thinnings	-	-	-	-	8,000.00	-	-	-	-	-	-	-	-	-	-
Final Clear Cut	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seed Production	-	-	-	-	5,000.00	4,000.00	5,500.00	7,000.00	8,500.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
Gov. Subsidy	800.00	700.00	600.00	500.00	400.00	-	-	-	-	-	-	-	-	-	-
Capital Costs:															
Opportunity Cost:															
Opportunity Cost	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
Site Preparation:															
Labor Costs	600.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tractor Costs	1,150.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Planting:															
Labor Costs	900.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equipment Costs	850.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seedling Costs	600.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fertilizer	116.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plantation Maintenance:															
Dead Tree Replacement:															
Seedling Costs	-	60.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Labor Costs	-	150.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Weeding and Fire Protection:															
Labor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tractor Costs	350.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00
Tree Pruning:															
Labor Costs	150.00	225.00	225.00	225.00	225.00	-	-	150.00	-	-	150.00	-	-	150.00	-
Equipment Costs	1,310.00	-	-	480.00	-	-	-	-	-	-	-	-	-	-	-
Fertilizer Costs:															
NPK (15-15-15) Costs	-	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00
Labor Costs	-	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
Insecticide Costs:															
Savin 85	270.00	270.00	270.00	270.00	270.00	-	-	-	-	-	-	-	-	-	-
Labor Costs	75.00	75.00	75.00	75.00	75.00	-	-	-	-	-	-	-	-	-	-
Equipment Costs	990.00	25.00	25.00	25.00	25.00	-	-	-	-	-	-	-	-	-	-
Seed Collection:															
Labor Costs	-	-	-	-	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00
Material Costs	-	-	-	-	14,500.00	-	-	-	-	-	-	-	-	-	14,500.00
Thinning Cost:															
Thinning Costs:															
Labor Costs	-	-	-	-	900.00	-	-	-	-	-	-	-	-	-	-
Equipment and Material Costs	-	-	-	-	540.00	-	-	-	-	-	-	-	-	-	-
Reserve Capital Costs:															
Reserve for Operating Costs	314.50	235.10	214.10	262.10	1,868.10	214.60	214.60	229.60	214.60	214.60	229.60	214.60	214.60	229.60	1,664.60
Inflation Margin:															
Inflation Margin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Benefits	800.00	700.00	600.00	500.00	13,400.00	4,000.00	5,500.00	7,000.00	8,500.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
Total Costs	12,675.50	7,586.10	7,355.10	7,883.10	25,549.10	7,360.60	7,360.60	7,525.60	7,360.60	7,360.60	7,525.60	7,360.60	7,360.60	7,525.60	23,310.60
Net Value:	(11,875.50)	(6,886.10)	(6,755.10)	(7,383.10)	(12,149.10)	(3,360.60)	(1,860.60)	(525.60)	1,139.40	2,639.40	2,474.40	2,639.40	2,639.40	2,474.40	(13,310.60)

Note: Seed Price = 5 Baht/Kg

Wood Price = 1,000 Baht/m^3

Table 3.10 continued

	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
Benefits:															
Commercial Thinnings	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Final Clear Cut	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seed Production	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
Gov. Subsidy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capital Costs:															
Opportunity Cost:															
Opportunity Cost	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
Site Preparation:															
Labor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tractor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Planting:															
Labor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equipment Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seedling Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fertilizer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plantation Maintenance:															
Dead Tree Replacement:															
Seedling Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Labor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weeding and Fire Protection:															
Labor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tractor Costs	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00
Tree Pruning:															
Labor Costs	-	150.00	-	-	150.00	-	-	150.00	-	-	150.00	-	-	150.00	-
Equipment Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fertilizer Costs:															
NPK (15-15-15) Costs	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00
Labor Costs	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
Insecticide Costs:															
Savin 85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Labor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equipment Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seed Collection:															
Labor Costs	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00
Material Costs	-	-	-	-	-	-	-	-	-	14,500.00	-	-	-	-	-
Thinning Cost:															
Thinning Costs:															
Labor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equipment and Material Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reserve Capital Costs:															
Reserve for Operating Costs	214.60	229.60	214.60	214.60	229.60	214.60	214.60	229.60	214.60	1,664.60	229.60	214.60	214.60	229.60	214.60
Inflation Margin:															
Inflation Margin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Benefits	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
Total Costs	7,360.60	7,525.60	7,360.60	7,360.60	7,525.60	7,360.60	7,360.60	7,525.60	7,360.60	23,310.60	7,525.60	7,360.60	7,360.60	7,525.60	7,360.60
Net Value:	2,639.40	2,474.40	2,639.40	2,639.40	2,474.40	2,639.40	2,639.40	2,474.40	2,639.40	(13,310.60)	2,474.40	2,639.40	2,639.40	2,474.40	2,639.40

Note: Seed Price = 5 Baht/Kg

Wood Price = 1,000 Baht/m^3

Table 3.10 continued

	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
Benefits:										
Commercial Thinnings	-	-	-	-	-	-	-	-	-	-
Final Clear Cut	-	-	-	-	-	-	-	-	-	116,029.70
Seed Production	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
Gov. Subsidy	-	-	-	-	-	-	-	-	-	-
Capital Costs:										
Opportunity Cost:										
Opportunity Cost	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
Site Preparation:										
Labor Costs	-	-	-	-	-	-	-	-	-	-
Tractor Costs	-	-	-	-	-	-	-	-	-	-
Planting:										
Labor Costs	-	-	-	-	-	-	-	-	-	-
Equipment Costs	-	-	-	-	-	-	-	-	-	-
Seedling Costs	-	-	-	-	-	-	-	-	-	-
Fertilizer	-	-	-	-	-	-	-	-	-	-
Plantation Maintenance:										
Dead Tree Replacement:										
Seedling Costs	-	-	-	-	-	-	-	-	-	-
Labor Costs	-	-	-	-	-	-	-	-	-	-
Weeding and Fire Protection:										
Labor Costs	-	-	-	-	-	-	-	-	-	-
Tractor Costs	350.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00
Tree Pruning:										
Labor Costs	-	150.00	-	-	150.00	-	-	150.00	-	-
Equipment Costs	-	-	-	-	-	-	-	-	-	-
Fertilizer Costs:										
NPK (15-15-15) Costs	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00	696.00
Labor Costs	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
Insecticide Costs:										
Savin 85	-	-	-	-	-	-	-	-	-	-
Labor Costs	-	-	-	-	-	-	-	-	-	-
Equipment Costs	-	-	-	-	-	-	-	-	-	-
Seed Collection:										
Labor Costs	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00
Material Costs	-	-	-	-	14,500.00	-	-	-	-	-
Thinning Cost:										
Thinning Costs:										
Labor Costs	-	-	-	-	-	-	-	-	-	-
Equipment and Material Costs	-	-	-	-	-	-	-	-	-	-
Reserve Capital Costs:										
Reserve for Operating Costs	214.60	229.60	214.60	214.60	1,679.60	214.60	214.60	229.60	214.60	214.60
Inflation Margin:										
Inflation Margin	-	-	-	-	-	-	-	-	-	-
Total Benefits	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	126,029.70
Total Costs	7,360.60	7,525.60	7,360.60	7,360.60	23,475.60	7,360.60	7,360.60	7,525.60	7,360.60	7,360.60
Net Value:	2,639.40	2,474.40	2,639.40	2,639.40	(13,475.60)	2,639.40	2,639.40	2,474.40	2,639.40	118,669.10

Note: Seed Price = 5 Baht/Kg

Wood Price = 1,000 Baht/m^3

3.4.2 *Sadao Tawai Plantation, tree spacing 6 X 6*

3.4.2.1 Benefits:

3.4.2.1.1 Quantifiable Benefits:

1. Income from the sale of collected neem flowers for human consumption.

The primary income from a Sadao Tawai plantation comes from the sale of neem flowers, which are eaten by the Thai's as a vegetable dish. The neem flower collection schedule starts in late September or early October and runs to the end of December. The trees do not stop producing flowers at the end of December, but collection is reported to stop at this time due to the drop in market price caused by the influx of regular season neem flowers into the market.

Mr. Vachira KhoPong, who discovered and registered the off-season flowering neem tree, indicates that during years two through four the plantation owner can make approximately 20 flower collection runs with each collection garnering 10 to 15 kilograms of flowers per rai. Later in years five through forty, the number of collection-runs per year increases to approximately 35 with each collection once again garnering 10 to 15 kilograms per rai. In order to provide a more conservative financial estimate, this study assumed that each collection-run brought in 10 kilograms of neem flowers per rai. Table 3.11 shows the Sadao Tawai flower collection schedule and total quantity of flowers collected during the life of the

Table 3.11 Sadao Tawai Flower Collection Quantities

Years	Number of Collections per Year	Flower Quantity per Collection (Kg/Rai)	Total Quantity of Flowers Collected per Year (Kg/Rai)
2 – 4	20	10	200
5 - 40	35	10	350

Source: Personal Communication with Mr. Vachira KhoPong, September 1997.

plantation investment.

During the study period, the market price for the Sadao Tawai flowers averages out to approximately 100 baht/kilogram. Flowers collected early on in the Sadao Tawai season are sold for at a price of 120 baht/Kg, but toward the end of the Sadao Tawai season when regular neem flowers are beginning to pour into the market, the Sadao Tawai flowers only achieve a price of 80 baht/Kg.

Nevertheless, the high flower price presently garnished by farmers selling

Sadao Tawai flowers will undoubtedly lead to increased cultivation of this variety of neem tree and to a larger supply of these off-season neem flowers. Hence, in accordance with the laws of supply and demand the relatively high average price of 100 baht/Kg will most likely be pushed down. It is for this reason that the average flower prices of 80 and 50 baht/kg were included into the analysis.

To evaluate the broadest possible potential for Sadao Tawai plantations, all three of these prices were considered in the financial analysis. The non-discounted annual cash in-flows from flower sales are represented for each different price level in Table 3.12.

Table 3.12 Annual Cash Inflow from Neem Flower Sales (Baht/Year)

		Average Flower Price (Baht/Kg)		
Years	**Total Quantity of Flowers Collected per Year (Kg/Rai)**	**50**	**80**	**100**
2 – 4	**200**	**10,000**	**16,000**	**20,000**
5 - 40	**350**	**17,500**	**28,000**	**35,000**

2. <u>Income from the sale of wood from final clear-cut for use in Charcoal or wood chip production</u>.

Unlike Sadao Thai trees, which have a definite end use as timber, the Sadao Tawai trees have a less than definite final use, because of the fact that the trees have been pruned short and forced to branch out. As such, the trees are not suitable for use as timber. The tree's bole and branches might be suitable for use in woodcarving. However, since the oldest trees presently in production are only about seven years old, it is nearly impossible to determine how large the boles and branches will become when the reach the ages of 15, 20, 30, and 40 years old. And, inasmuch as demand for neem trees for use in woodcarving has not yet risen, it is unlikely that the trees will have any other final use other than for charcoal or wood chip production. Neem is well suited for use in charcoal production as it is a hot burning wood.

This study chose to two per tree stumpage price levels for use in the financial analysis of the Sadao Tawai plantation investment. Table 3.13 shows these two price levels and depicts the non-discounted cash inflow derived from the Sadao Tawai clear-cut.

Table 3.13 Financial Returns from Sadao Tawai Clear-cut		
Stumpage Price (Baht/Tree)	**Number of Trees per Rai**	**Non-Discounted Cash Inflow (Baht/Rai)**
200	**64**	**12,800**
300	**64**	**19,200**

3. Income from Thai Government Afforestation Subsidy.

The Sadao Tawai Investments do not qualify for the Thai Government afforestation subsidy, because the plantation size is only 64 trees instead of the two hundred required by the Royal Forestry Department.

3.4.2.1.2 Unquantifiable Economic and Environmental Benefits:

1. An increase in soil quality.

As was explained in section 3.4.1.1.2, the leaves of the neem tree help to lower soil acidity while also bringing nutrients that had been locked deep down in the soil up to the surface.

2. Water retention.

Sadao Tawai trees can help the soil retain water longer by providing shade that slows the rate of evaporation by the sun's hot rays.

3. An increase in carbon stocks and a decrease in CO_2 levels in the atmosphere.

Investing in a Sadao Tawai plantation gives nature the opportunity to capture carbon and lower carbon dioxide levels in the atmosphere through photosynthesis by the trees in the plantation.

4. Creation of microclimates.

Sadao Tawai plantations could possibly create beneficial microclimates such as areas that have higher humidity and lower temperatures during the hot season.

5. An increase in domestic firewood supply.

As the Sadao Tawai trees grow older and flower production begins to decline, farmers will start to have an incentive to remove the old trees and plant new trees or change over to a different crop system. Either way, the removal of the older trees will generate supplies of high quality firewood, which could be used or sold in its original form or as charcoal.

3.4.2.2 Capital Costs:

Many of the capital costs associated with a Sadao Tawai plantation are estimated to be identical to a Sadao Thai plantation. The reason for this relates to the fact that both Sadao Tawai and Sadao Thai are different varieties of the same tree species. Therefore, descriptions of some of the capital costs below reference more detailed descriptions given in the discussion of Sadao Thai capital costs.

1. Site Preparation Costs for the First Year of the Project

Site preparation cost, i.e. the costs of clearing away scrub and underbrush, and of hiring tractors to grade and plow the plantation site, in total comes to 1,150 baht, which is the same as the estimated costs of site preparations for a Sadao Thai investment site.

2. Planting Costs for the First Year of the Project

2.1 <u>Seedling Costs</u>.

Mr. Vachira KhoPong's company sells the Sadao Tawai seedlings for 150 baht per tree. These seedlings are a great deal more expensive than the Sadao Thai seedlings, because more time goes into preparing them. Each seedling is actually a Sadao Tawai shoot grafted on to a regular Sadao Thai rootstock. Based on a plantation spacing of 5x5 meters, 64 trees will be needed per rai. As such, the cash out-flow for the seedlings sums to 9,600 baht per rai.

2.2 <u>Labor Costs</u>.

The labor costs associated with laying out the planting site, digging holes, applying fertilizer, and planting the Sadao Tawai plantation are the same as the labor expenditure for a Sadao Thai plantation. A detailed explanation is given in section 3.4.1.2: 2.2.

2.3 <u>Equipment Costs</u>.

The equipment costs in setting up a Sadao Tawai plantation are identical to those of a Sadao Thai plantation. For a description of these costs, please see section 3.4.1.2: 2.3.

2.4 <u>Fertilizer</u>.

Mr. Vachira KhoPong suggests that each tree be given 500 grams of

NPK 15-15-15 fertilizer in the first year. Therefore, the total quantity of fertilizer needed per rai adds up to 32 kilograms. Based on a per kilogram cost of fertilizer of 10.4 baht, the cash out-flow for first year fertilizer is 332.80 baht.

3. Plantation Maintenance Costs for the First Year through the 40th Year of the Project

3.1 New seedling replacement of dead seedlings.

3.1.1 Cost of replacement seedlings.

As was stated earlier, Neem tree seedlings are extremely hardy and have shown a strong survival rate. The Sadao Tawai seedlings should be even hardier than the Sadao Thai seedlings due to the fact that the root ball and stem have been given more time to develop in the nursery. Therefore seedling mortality should be some what less than that of the Sadao Thai seedlings. This study used a 6% mortality rate for the Sadao Tawai seedlings. By applying the 6 percent mortality safety margin to the 64 trees in the Sadao Tawai plantation, it was estimated that four trees would need to be replaced. Because the trees cost 150 baht a piece, the total cash out-flow for replacement seedlings comes to 600 baht.

3.1.2 Labor costs associated with seedling replacement.

Since only four trees need to be replaced, it should only take half a labor day to dig the holes, apply fertilizer, and then plant the trees. Thus, the cash out flow for this is 75 baht.

3.2 Weeding and Fire Protection.

The cash out-flows attributed to weeding and fire protection in a Sadao Tawai plantation are also identical to those of a Sadao Thai plantation.

3.3 Tree pruning.

3.3.1 Labor costs associated with tree pruning.

Where as pruning in a Sadao Thai plantation is conducted in order influence the neem trees to grow up straight and tall, pruning has a totally different purpose in a Sadao Tawai plantation. The goal of pruning here is to influence the neem trees to branch out close to the ground and to keep the short for more convenient flower collection. If the trees are not pruned short, flowers budding on higher branches will be inaccessible and income will be lost. Because of the need to keep the Sadao Tawai neem variety short and bushy, a large degree of pruning must be conducted in every year of the investment.

Table 3.14 shows the pruning schedule and the cash out-flows associated with it. In year one, pruning only takes place once, and requires two labors two labors to prune and clear off all of the clippings. In the following years of the investment, pruning takes place twice and year and demands four labor days total to prune and

Table 3.14 Sadao Tawai Plantation Pruning Schedule and Labor Costs

Year	Number of Prunings per Year	Number of Labor Days per Pruning	Total Number of Labor Days per Year per Rai	Total Cost of Labor (Baht/Rai/Year)
1	1	2	2	300.00
2 - 40	2	2	4	600.00

Source: Personal Communications with Vachira KhoPong, September 1997.

clear off all of the cut limbs and branches.

3.3.2 Equipment costs.

3.3.2.1 Clippers

One pair of hand clippers will be used for both pruning and harvesting the neem flowers. The hand clippers have a usage life of five years and is priced at 620 baht per pair. Because the clippers have a usage life of only five years, a new pair must be purchased in years 6, 11, 16, 21, 26, 31, and 36.

3.3.2.2 Lopping Shears

Priced at 380 baht per pair and also having a usage life of five years, one pair of lopping shears will be used primarily for pruning, but might also be used for flower collection. The replacement schedule for the lopping shears is the same as that for the hand clippers.

3.3.2.3 Hand Saws

One hand saw must be purchased every five years for pruning large limbs and branches which cannot be pruned using either the clippers or lopping shears. The hand saw was priced in a local Chiang Mai market at 270 baht per saw.

3.4 Fertilizer Costs.

3.4.1 Chemical fertilizer costs.

A major capital expense, the cost of chemical fertilizers is an

Table 3.15 Sadao Tawai Fertilizing Schedule

Year	Number of Trees/Rai	Fertilizer Kg/Tree/Time	Number of Fertilizings/Year	Total Kg/Tree/Year	Total Kg/Rai/Year
1	64	0.5	1	0.5	32
2	64	0.5	2	1.0	64
3	64	0.75	2	1.5	96
4	64	1.0	2	2.0	128
5 - 40	64	1.5	2	3.0	192

Source: Personal Communication with Vachira KhoPong, September 1997.

important component in the financial analysis of the Sadao Tawai plantation investment. The suggested per tree fertilizer amounts for the Sadao Tawai plantation is approximately twice as much as that suggested for the Sadao Thai plantation. Mr. Vachira KhoPong recommends that the amount of fertilizer applied to his trees follow the guidelines set for fruit trees. These amounts are presented in Table 3.15. Table 3.16 shows the yearly Sadao Tawai plantation cash out-flows from fertilizer

Table 3.16 Yearly Sadao Tawai Plantation Cash Out-Flows from Fertilizer Expenditures

Year	Number of Trees/Rai	NPK 15-15-15 Kg/Rai/Yea	Total Cash Out-Flow† Baht/Rai/Year
1	64	32	332.80
2	64	64	665.60
3	64	96	998.40
4	64	128	1,331.20
5 - 40	64	192	1,996.80

† Cash out-flows based on fertilizer price of 10.4 Baht/Kg.

purchases.

3.4.2 Labor costs associated with tree fertilizing.

Even though a Sadao Tawai plantation has a smaller number of trees per rai than a Sadao Thai plantation, the labor costs associated with tree fertilizing was held constant with that of the Sadao Thai plantation. The reasoning behind this is that even though there are fewer trees, the laborer has to move a larger amount of fertilizer around the plantation thereby taking him longer to fertilize.

3.5 Insecticide Costs.

3.5.1 Insecticide costs.

Like the Sadao Thai neem tree, the Sadao Tawai variety is also susceptible to spider mites and scales, and therefore is also it is necessary to use a certain amount of pesticide in each year of the investment in order to protect the trees from being stunted or killed back by these insects. Due to the fact that Sadao Tawai trees are pruned short, it is easier to control insect infestations. As such, this study expects that a Sadao Tawai plantation owner will use a one kilogram bag of *Savin 85* each year for the length of the investment. The recorded cost of a one kilogram bag of *Savin 85* was 210 baht.

3.5.2 Labor costs associated with insecticide application.

Since the Thai neem tree suffers from only a small variety of insect pests, this study estimates that only half a man day will be used each year to apply needed insecticide. This relates to a cash out-flow of 75 baht per year.

3.5.3 Equipment costs.

One shoulder carried sprayer must be purchased to spray on the necessary insecticide. A sprayer with a metal tank is estimated to half a usage life of 10 years, and is presently priced at 990 baht per unit. Because the sprayer only has a ten year usage life, a new sprayer must be purchased every ten years till the end of the investment.

In addition to the cost of the sprayer, each year spare parts need to be purchased for the sprayer as well. The spare parts in the form of rubber seals will cost approximately 50 baht each year to replace. In approximately the fifth year of the units life, the pump mechanism, priced at 180 baht, will mostly likely have to be replaced as well.

4. Flower Collection Costs in the 2nd to the 40th Year of the Project

4.1 Labor costs associated with flower collection.

Mr. Vachira KhoPong, owner of the Sadao Tawai Company, expressed his expert opinion that during the years 2-4 one laborer will spend twenty half labor days collecting and sorting neem flowers from a one rai plantation. During years 5-40, it is expected that a plantation laborer will spend 35 full labor days collecting and sorting neem flowers. Mr. KhoPong bases his estimates on a flower collection schedule that starts in late September or early October and runs to the end of December. The trees do not stop producing flowers at the end of December, but Mr. KhoPong stops collecting in December because of the drop in price due the influx of regular season neem flowers into the market. The total cash out-flow for flower collection labor is shown in Table 3.17.

Table 3.17 Yearly Labor Costs Associated with Neem Flower Collection

Year	Number of Flower Collections per Rai	Number of Labor Days per Collection	Total Number of Labor Days per Rai	Total Cost of Labor (Baht/Rai)
2 - 4	20	0.5	10	1,500.00
5 - 40	35	1.0	35	5,250.00

Source: Personal Communication with Vachira KhoPong, September 1997.

4.2 Equipment costs.

This study makes the assumption that plantation laborers will use the same tools to collect the flowers as they do to prune, and hence the cost of flower collecting equipment was not figured into the financial analysis so as to avoid double counting.

Table 3.18 summarizes the Sadao Tawai investment cash in-flows and out-flows for an investment forty years in length. Shorter investment lengths show cash in-flows and out-flows almost identical to the ones given below, except that they come earlier.

Table 3.18 Forty Year Sadao Tawai Normal Investment Analysis Including a 5,000 Baht Opportunity Cost

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Benefits:															
Flower Production	-	10,000.00	10,000.00	10,000.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00
Final Clear Cut	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capital Costs:															
Opportunity Cost:															
Opportunity Cost	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
Site Preparation:															
Labor Costs	600.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tractor Costs	1,150.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Planting:															
Labor Costs	9,600.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equipment Costs	900.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seedling Costs	714.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fertilizer	371.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plantation Maintenance:															
Dead Tree Replacement:															
Seedling Costs	-	600.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Labor Costs	-	150.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Weeding and Fire Protection:															
Labor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tractor Costs	350.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00
Tree Pruning:															
Labor Costs	300.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00
Equipment Costs	860.00	720.00	-	-	-	860.00	720.00	-	-	-	860.00	720.00	-	-	-
Fertilizer Costs:															
NPK (15-15-15) Costs	-	742.40	1,113.60	1,484.80	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20
Labor Costs	-	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
Insecticide Costs:															
Savin 85	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00
Labor Costs	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Equipment Costs	990.00	25.00	25.00	25.00	180.00	25.00	25.00	25.00	25.00	25.00	990.00	25.00	25.00	25.00	180.00
Flower Collection:															
Labor Costs	-	1,500.00	1,500.00	1,500.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00
Reserve Capital Costs:															
Reserve for Operating Costs	284.50	553.24	443.36	480.48	945.22	1,015.72	1,001.72	929.72	929.72	929.72	1,112.22	1,001.72	929.72	929.72	945.22
Inflation Margin:															
Inflation Margin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Benefits	-	10,000.00	10,000.00	10,000.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00
Total Costs	21,464.70	11,085.64	9,876.96	10,285.28	15,397.42	16,172.92	16,018.92	15,226.92	15,226.92	15,226.92	17,234.42	16,018.92	15,226.92	15,226.92	15,397.42
Net Value:	(21,464.70)	(1,085.64)	123.04	(285.28)	2,102.58	1,327.08	1,481.08	2,273.08	2,273.08	2,273.08	265.58	1,481.08	2,273.08	2,273.08	2,102.58

Note: Flower Price = 50 Baht/Kg

Wood Price = 200 Baht/Tree

Table 3.18 continued

	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
Benefits:															
Flower Production	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00
Final Clear Cut	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capital Costs:															
Opportunity Cost:															
Opportunity Cost	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
Site Preparation:															
Labor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tractor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Planting:															
Labor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equipment Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Seedling Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fertilizer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plantation Maintenance:															
Dead Tree Replacement:															
Seedling Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Labor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weeding and Fire Protection:															
Labor Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tractor Costs	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00
Tree Pruning:															
Labor Costs	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00
Equipment Costs	860.00	720.00	-	-	-	860.00	720.00	-	-	-	860.00	720.00	-	-	-
Fertilizer Costs:															
NPK (15-15-15) Costs	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20
Labor Costs	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
Insecticide Costs:															
Sevin 85	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00
Labor Costs	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Equipment Costs	25.00	25.00	25.00	25.00	25.00	990.00	25.00	25.00	25.00	180.00	25.00	25.00	25.00	25.00	25.00
Flower Collection:															
Labor Costs	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00
Reserve Capital Costs:															
Reserve for Operating Costs	1,015.72	1,001.72	929.72	929.72	929.72	1,112.22	1,001.72	929.72	929.72	945.22	1,015.72	1,001.72	929.72	929.72	929.72
Inflation Margin:															
Inflation Margin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Benefits	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00
Total Costs	16,172.92	16,018.92	15,226.92	15,226.92	15,226.92	17,234.42	16,018.92	15,226.92	15,226.92	15,397.42	16,172.92	16,018.92	15,226.92	15,226.92	15,226.92
Net Value:	1,327.08	1,481.08	2,273.08	2,273.08	2,273.08	265.58	1,481.08	2,273.08	2,273.08	2,102.58	1,327.08	1,481.08	2,273.08	2,273.08	2,273.08

Note: Flower Price = 50 Baht/Kg

Wood Price = 200 Baht/Tree

Table 3.18 continued

	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
Benefits:										
Flower Production	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00
Final Clear Cut	-	-	-	-	-	-	-	-	-	12,800.00
Capital Costs:										
Opportunity Cost:										
Opportunity Cost	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
Site Preparation:										
Labor Costs	-	-	-	-	-	-	-	-	-	-
Tractor Costs	-	-	-	-	-	-	-	-	-	-
Planting:										
Labor Costs	-	-	-	-	-	-	-	-	-	-
Equipment Costs	-	-	-	-	-	-	-	-	-	-
Seedling Costs	-	-	-	-	-	-	-	-	-	-
Fertilizer	-	-	-	-	-	-	-	-	-	-
Plantation Maintenance:										
Dead Tree Replacement:										
Seedling Costs	-	-	-	-	-	-	-	-	-	-
Labor Costs	-	-	-	-	-	-	-	-	-	-
Weeding and Fire Protection:										
Labor Costs	-	-	-	-	-	-	-	-	-	-
Tractor Costs	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00
Tree Pruning:										
Labor Costs	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00	600.00
Equipment Costs	860.00	720.00	-	-	-	860.00	720.00	-	-	-
Fertilizer Costs:										
NPK (15-15-15) Costs	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20	2,227.20
Labor Costs	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
Insecticide Costs:										
Savin 85	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00	270.00
Labor Costs	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Equipment Costs	990.00	25.00	25.00	25.00	180.00	25.00	25.00	25.00	25.00	25.00
Flower Collection:										
Labor Costs	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00
Reserve Capital Costs:										
Reserve for Operating Costs	1,112.22	1,001.72	929.72	929.72	945.22	1,015.72	1,001.72	929.72	929.72	929.72
Inflation Margin:										
Inflation Margin	-	-	-	-	-	-	-	-	-	-
Total Benefits	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	17,500.00	30,300.00
Total Costs	17,234.42	16,018.92	15,226.92	15,226.92	15,397.42	16,172.92	16,018.92	15,226.92	15,226.92	15,226.92
Net Value:	265.58	1,481.08	2,273.08	2,273.08	2,102.58	1,327.08	1,481.08	2,273.08	2,273.08	15,073.08

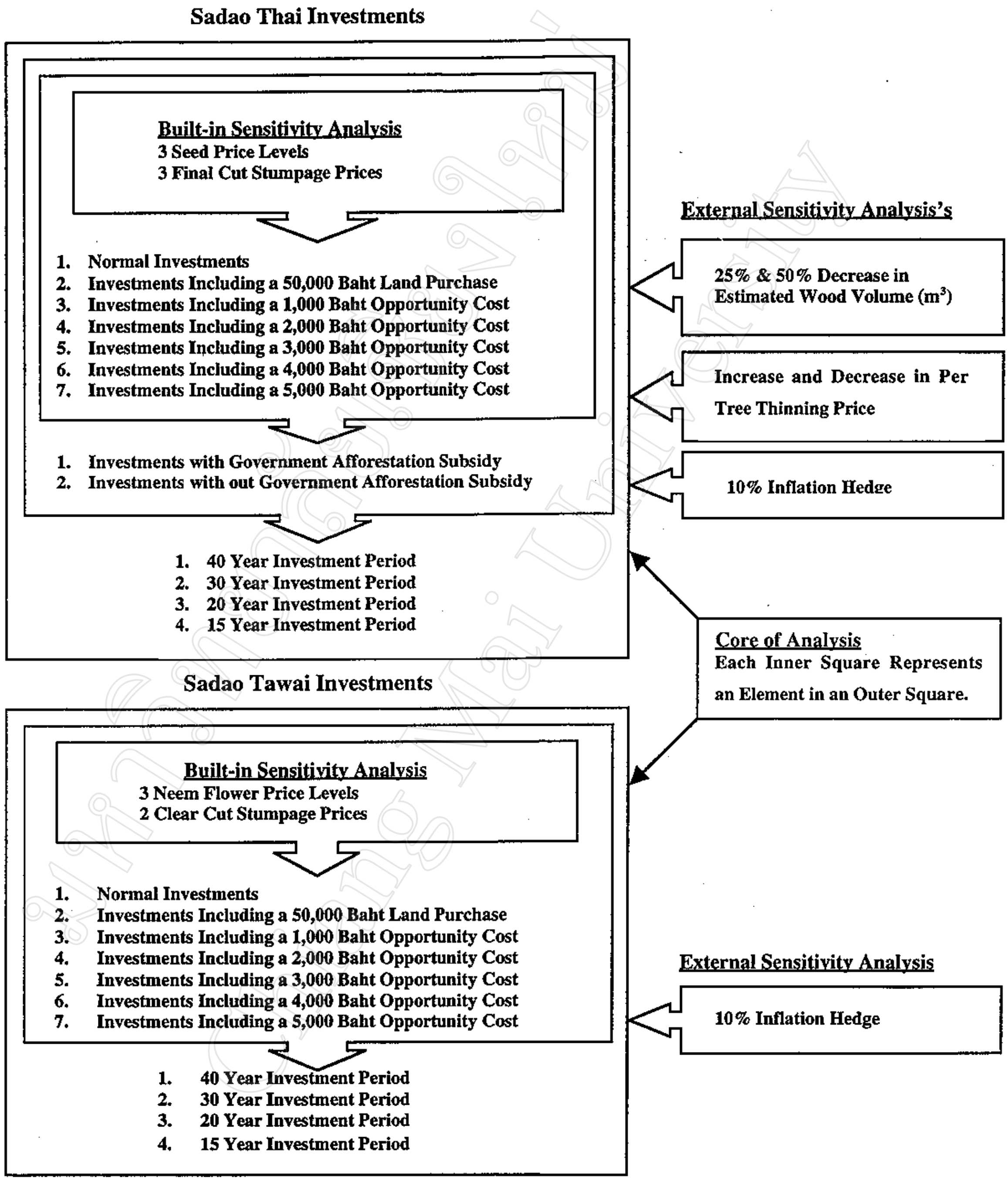
Note: Flower Price = 50 Baht/Kg

Wood Price = 200 Baht/Tree

3.5 Description of Sensitivity Analysis

The sensitivity analysis used in this study was made up of two components. The first component, here called the Built-in Sensitivity Analysis, was comprised of a group of core investment variables, whose influence over the financial viability of each type of investment was to checked at every step of the sensitivity analysis. The External Sensitivity Analysis, the second component, was made up of only a few variables. However, whereas a change in one of the built in variables only effected the financial viability of a certain investment situation, a change in one of the external variables effected the viability of every investment situation investigated. Figure 3.1 illustrates the flow of the sensitivity analysis conducted in this study.

Figure 3.1 Sensitivity Analysis Flow Chart



Because the major goal of this study was to investigate the financial potential of both Sadao Thai and Sadao Tawai investments, the sensitivity analysis of a group of core variables was built into the financial analysis model. Investment specific variables for Sadao Thai investments included the inclusion of a government afforestation subsidy, three neem seed price levels, three Sadao Thai final cut stumpage price levels, and one thinning price level. The core variables for the Sadao Tawai investments included three neem flower price levels and two clear cut stumpage levels. Beyond these investment specific levels, both investment types also independently examined of the effects of including various types of opportunity costs, and the cost of a land purchase to the normal investment. Then all of these situations were investigated again at shorter investment periods.

3.5.1 Sadao Thai Investments

3.5.1.1 Sadao Thai Built-in Sensitivity Analysis

3.5.1.1.1 Seed and Stumpage Prices

The financial viability of a Sadao Thai plantation investment was studied using three different seed and stumpage prices in nine different combinations. These combinations are shown in Table 3.19. Each combination represents one possible market situation that an investor might encounter, and thus represents one possible financial outcome. These nine combinations provide the fundamental structure for cash in-flows.

Table 3.19 Seed and Wood Price Combinations

Combination	#1	#2	#3	#4	#5	#6	#7	#8	#9
Seed Price (Baht/Kg)	5.00	5.00	5.00	10.00	10.00	10.00	15.00	15.00	15.00
Wood Price (Baht/m^3)	1,000	5,000	10,000	1,000	5,000	10,000	1,000	5,000	10,000

3.5.1.1.2 Opportunity Costs

The opportunity cost of setting up a neem plantation in any specific region of the country is the loss of income from not planting the major economic crop in that region. The three regions of interest in this study were the Central, Northern, and

Northeastern regions. Because Sadao Thai does not grow well in the Southern region of Thailand, it was not included in the analysis.

According to the most recent agricultural census, which was conducted in 1993, three of the most predominant crops in all three regions were corn (maize), cassava, and sugarcane. In the Central region sugarcane was the most widely cultivated field crop with a total of 2,619,663 rai being planted (1993 Agricultural Census, Central Region). The most widely planted field crop in the Northern region was corn which saw a total area of 3,395,183 rai being cultivated (1993 Agricultural Census, Northern Region). In the Northeastern region cassava showed the greatest area of cultivation than any other field crop with a total cultivated area of 6,185,025 rai (1993 Agricultural Census, Northeastern Region).

The reader can see from Table 3.20 that the Baht/Rai average income from each of these three crops was almost the same. As a result of this, the analysis results from using each of these incomes as an independent opportunity cost would be, for all intents and purposes, nearly identical. In order to avoid duplicating the same results and in order to include other potentially larger crop returns, this study used opportunity costs set at one, two, three, four and five thousand Baht respectively. The 5,000 Baht sum was considered a catch all for unexpected costs and as an additional economic rent for crops that produce net-incomes of more than 4,000 Baht per year.

Table 3.20 Major Regional Economic Crops and the Average Net-Income they Provide

Region	Major Economic Crop	National Average Net-Income (Baht/Rai) from Crop Cultivation†
Central	Sugarcane	756.16
North	Corn	799.29
Northeast	Cassava	728.44

† Source: Office of Agricultural Economics

3.5.1.1.3 Land Purchase

The cost of purchasing a one-rai plot of land priced at 50,000 baht in order to set up a plantation was also included in the built-in sensitivity analysis. The 50,000 baht price was based on the estimated cost of titled land near the city of Wiang Pa Pao in Chiang Rai province. The predicted cash out-flow for the purchase was based on a five-year agricultural loan from the Suthep road branch of Bangkok Bank Limited. In October of 1997 the bank quoted a loan rate of 1,026.64 baht per month for five years. This translates into a yearly cash out-flow of 12,319.68 baht. The interest rate for the five-year loan was 18.25% and was denominated by the MRR, at that time being 14.5%, plus a fixed rate of 3.75%.

3.5.1.1.4 Investments with and with out Government Afforestation Subsidy

For the Sadao Thai investment analysis all investments were assessed with and with out the 3,000 baht Thai government afforestation subsidy to estimate the level to which the subsidy enhanced the financial viability of the plantation investment under varying economic constraints.

3.5.1.1.5 Investment Lengths

Four investment periods of different lengths were included in the core analysis. The investment periods evaluated were 40, 30, 20, and 15 years in length with the 40-year investment period being considered the normal investment length. The reason for checking the plantation investment's sensitivity to changes in investment length was to determine which investment length would maximize returns.

3.5.1.2 Sadao Thai External Sensitivity Analysis's

3.5.1.2.1 Decreases in Estimated Wood Volume (m^3)

In order to assess how sensitive the investment indicators (NPV, B/C ratio, and IRR) in every investment situation were to changes in the estimated Sadao Thai wood volume, the investment analysis was consecutively re-run after first decreasing the estimated wood volume by 25 percent and then again after reducing it by 50 percent.

3.5.1.2.2 Increase and Decrease in Per Tree Thinning Price

As was explained in section 3.4, three possible thinning proxy-prices have been identified as being 50, 80, and 175 baht per tree (See Table 3.3). The normal analysis only considers the investment's viability at the 80 baht per tree price level.

Therefore, to more fully understand the investment's sensitivity to changes in thinning price, the external sensitivity analysis was run at both the 50 and 175 baht per tree level.

3.5.1.2.3 10% Inflation Hedge

The problem of inflation was not considered in the normal investment analysis due to the difficulty in predicting inflation and its effects on prices. In order to address the effects of inflation on the financial potential of the Sadao Thai investment, the yearly operation and working capital costs were increased by ten percent while the benefits gained from seed and wood sales were held constant. The ten percent increase in these costs represents the possible increase in over all costs attributed to a rise in labor and material prices due to inflation.

3.5.2 Sadao Tawai Investments

3.5.2.1 Sadao Tawai Built-in Sensitivity Analysis

3.5.2.1.1 Flower and Wood Prices

The financial viability of a Sadao Tawai plantation investment was studied using three different flower price levels and two per tree stumpage price levels. By matching each flower price level with a stumpage price level, six different combinations were formed. These combinations are shown in Table 3.21. Each combination represents one possible market situation that an investor might encounter, and thus represents one possible financial outcome. These six combinations provide the fundamental structure for the Sadao Tawai investment's financial returns.

Table 3.21 Flower and Wood Price Combinations

Combination	#1	#2	#3	#4	#5	#6
Flower Price (Baht/Kg)	50.00	50.00	80.00	80.00	100.00	100.00
Wood Price (Baht/Tree)	200.00	300.00	200.00	300.00	200.00	300.00

3.5.2.1.2 Opportunity Costs

The opportunity costs considered in the Sadao Tawai investment analysis were the same as those in the Sadao Thai investment analysis described above.

3.5.2.1.4 Land Purchase

The same land purchase scenario described above for the Sadao Thai analysis was used for the Sadao Tawai investment analysis.

3.5.2.1.5 Investment Lengths

In order to be able to compare Sadao Tawai investments against Sadao Thai investments at every investment length and in order to check the Sadao Tawai investment's sensitivity to shorter investment periods, investment lengths of 40, 30, 20, 15 years were incorporated into the Sadao Tawai built-in sensitivity analysis.

3.5.2.2 Sadao Tawai External Sensitivity Analysis

3.5.2.2.1 10% Inflation Hedge

The same as in the Sadao Thai investment analysis, the yearly operating and working capital costs were increased by ten percent to estimated the effects of inflation on the Sadao Tawai investment returns.

3.6 Description of The Methods Used in Estimating Sadao Thai Wood Volume

At the outset of doing research for this paper, it was believed that data pertaining to annual seed and wood production quantities was not only available but also accessible. Unfortunately, this was not the case for both seed or wood production as either no data had been collected or was to preliminary to be of much benefit for this study. Fortunately, in the case of seed production there were several neem experts who were able to provided educated estimates. However, this was not the case for wood production for several reasons. First, as a minor commercial wood species, very little attention has been given to the neem tree in regards of using it for commercial timber production. Instead, most of the literature published on the neem tree has focused on its potential for use in reforestation and afforestation of dryer regions where other tree species fail to grow well. Because of this, greater interest has been given to researching survival rates as opposed to researching neem timber production. Second, because all of the Sadao Thai plantations, which have been set up for seed production, are still relatively young, long term growth data is still unavailable from them.

Faced with this problem, it became necessary to develop a statistical method for estimating a preliminary per tree wood volume for years 15, 20, 30, and 40. The system devised for this purpose has three parts. The first part of this system is the estimation of annual DBH (diameter at breast height) growth for the neem tree. The second part entails finding the relationship between DBH and wood volume, and then generating a wood volume to DBH, growth curve. Finally, annual wood volume growth is predicted by inputting the estimated annual DBH's into the equation expressing the relationship between wood volume and DBH. The following three sections describe the wood volume estimation is greater detail.

3.6.1 Estimation of the annual DBH growth curve

The estimation of the annual growth in DBH was conducted by running a regression of DBH on tree age. Data for the regression was collected from two primary sites. The first site used for data collection was a neem test plantation established at the Ratchaburi Forest Experiment Station of the Royal Forestry Department in Ratchaburi province by Dr. Pongsak Sahunalu from the Faculty of Forestry, Kasetsart University for the purpose of researching neem biomass and self-thinning due to over crowding. Trees planted at the site were spaced at .5x.5, 1x1, 2x2, 4x4, 6x6, and 8x8 meters, and since being planted had not been pruned or fertilized. In addition to this, the soil at the site is described as being Lateritic in type, composed of high percentages of heavy clay, rock fragments and secondary formed irony gravel, and the site's climate is described as being among the driest regions in Thailand (Thoranisorn, 1985). For these reasons and the belief that a well maintained and fertilized plantation with closer spacings would show growth rates comparable to the trees planted in the test plantation at a 8x8 spacing, data from the 8x8-tree spacing was used as proxy for the Sadao Thai plantation with a 4x2 spacing. The data used from this site was secondary data that had been collected and averaged during years 1 through 6 by Dr. Thoranisorn for use in his doctoral dissertation (Thoranisorn 1985, and personal communication with Dr. Thoranisorn), and during years 7 and 8 by Vicharn Prueksakorn (Vicharn 1992[1]). In addition to the plantation data, the DBH of a large singular Thai neem tree, which was located in a local Wat approximately 5 Km from the plantation, was also measured and included in the Ratchaburi data set. Even though this tree was not located in the immediate area of the test plantation, it was included into the data set due to its large size and known age of 58 years.

Due to the fact that the Ratchaburi site couldn't provide DBH data for medium aged trees, a second set of data was collected from Ko Saliam village in Chiang Mai province. Translated from Northern Thai, Ko Saliam translates directly to "neem tree cluster village." According to the village headman, the village was established approximately 100 years ago around a large neem tree, which being the tallest tree in the area provided a vantage point from which the city of Chiang Mai could be seen. Due to the local historical relevance of the neem tree and the number of neem trees in the area, Ko Saliam village offered the opportunity to measure DBH's from older trees of known age. In total, six trees of known age were measured. The six trees represented five different age groups ranging from 12 to 70 years old. All of the trees measured were growing far enough away from any other tree so as not to have to compete for light and space like a tree planted in a plantation.

It should be noted here that collecting data from two totally different sites, such as those in Ratchaburi and Chiang Mai, for the purpose of finding a DBH growth curve is definitely not the most optimal situation. Differences in soil composition, climate, and tree genetics can all lead to large disparities in growth rates from region to region. However, the lack of long-term data regarding neem growth rates and the fact that age and growth rate data cannot be gleaned from studying the neem tree's growth rings meant that acquiring more accurate data was beyond the scope and time limits of this study.

The data collected from both sites was analyzed using linear regression in order to estimate an annual DBH growth curve. The regression equation derived from analyzing the collected data is given above. The equation shows that the diameter at breast height (DBH) is a function of the age of the tree (t).

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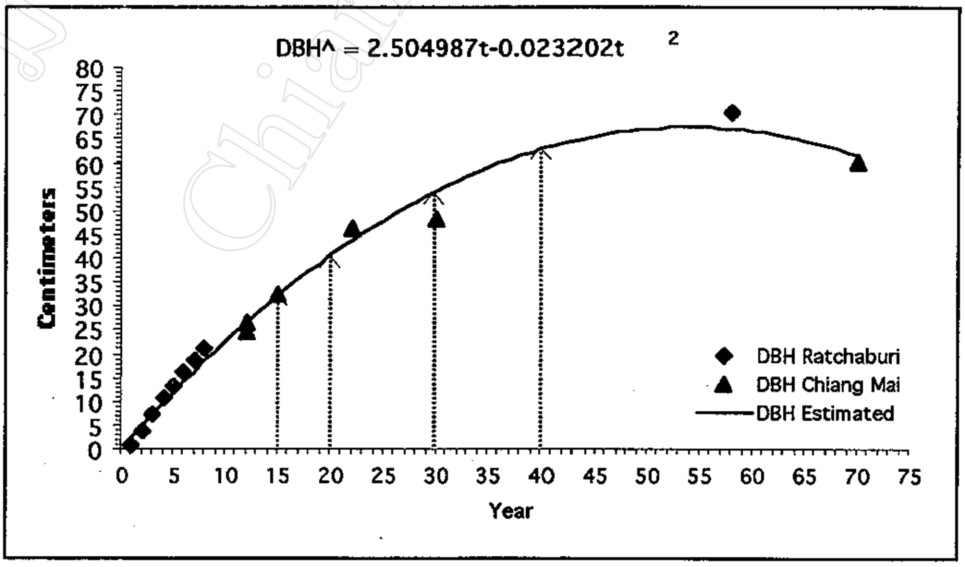
[1] Please see **Vicharn 2536** in the Thai Language Bibliography

$$\text{Estimated DBH} = \underset{(28.136)}{\underset{(0.089030)}{2.504987t}} - \underset{(-15.563)}{\underset{(0.001491)}{0.023202t^2}}$$

Multiple R	0.99728	Standard Error	2.70527
R Square	0.99457	Durbin-Watson Test	2.67001
Adjusted R Square	0.99367		
Standard Error	2.70527		
Durbin-Watson Test	2.67001		

Figure 3.2 graphically depicts the estimated DBH growth curve and the observed DBH data points. The dashed lines are drawn into the graph to point out the estimated DBH's for each of the investment lengths analyzed, these being 15, 20, 30, and 40 years. Because a quadratic curve was used to fit the observed data, the estimated DBH growth curve begins to decrease in value after year 55. In reality, a tree's DBH would never decrease, but would instead continue to increase at a very slow rate or would remain constant. This, therefore, points to a flaw in the DBH estimation method. However, since the maximum investment length considered was 40 years, which was a time period still uninfluenced by this problem, no effort was made to solve it.

Figure 3.2 Estimated Annual DBH Growth Curve

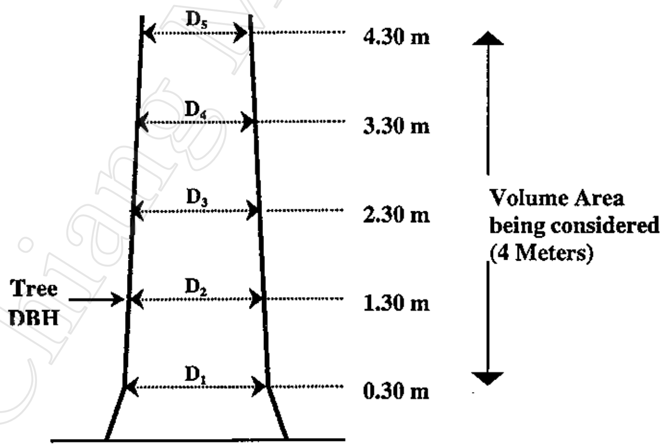


3.6.2 Estimation of the Wood Volume to DBH Growth Curve

The estimation of the growth in per tree wood volume was conducted by running a regression of wood volume on tree DBH. The fundamental concept behind running a regression of wood volume on tree DBH was that trees with differing DBH's would have different wood volumes, i.e. a tree with a large DBH would have a greater wood volume than a tree with a smaller DBH. Because the price for teak logs were quoted in four meter lengths, this study only considered the volume for a four meter long neem log.

In order to run the regression, volume data was collected from Chaiyaphum, Khon Kaen and Ratchaburi provinces by measuring the Diameter of neem trees at the heights of 0.30, 1.30, 2.30, 3.30, and 4.30 meters. Figure 3.3 shows the diameters (D) measured on the tree trunk. The measurement heights started at 0.30 meters as this would most likely be the height at which the felling cut would be made. From this point, measurements were taken every one meter till the height of 4.30 meters. After

Figure 3.3 Tree Diameter Measurement Diagram

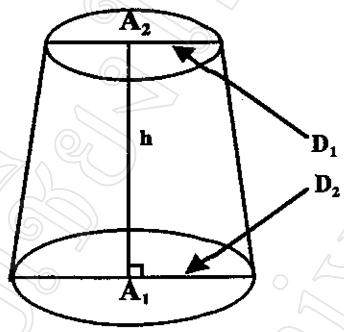


the diameter at each height had been measured, the surface area passing through the tree trunk at each diameter was calculated using the area equation presented in Figure 3.4. The wood volume of the trunk was then calculated by finding the volume between each measured point using the volume of a cylinder equation also given in Figure 3.4. These four volumes were then summed together to give the total wood volume.

Figure 3.4 Calculation of Tree Trunk Volume

Area of $A_1 = (D_1/2)^2 \Pi$

Volume of a Cylinder $= \left(\frac{A_1 + A_2}{2}\right) h$



The data collected from all three sites was analyzed using regression technique as in the estimation of the annual DBH growth curve. The regression equation derived from analyzing the collected data is given below. The equation shows that the wood volume (WV) is a function of the diameter at breast height (DBH).

$$\mathbf{WV = 0.000402(DBH) - 0.00028526(DBH)^2}$$

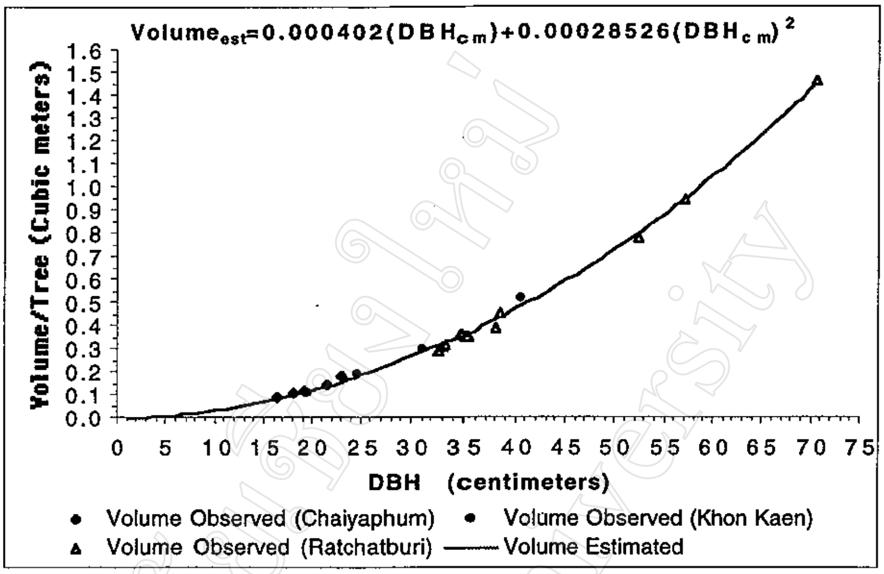
(3.3160E-04) **(6.8642E-06)**

(1.213) **(41.557)**

R Square	0.99894
Adjusted R Square	0.99882
Standard Error	0.01771
Durbin-Watson Test	1.74552

Figure 3.5 depicts graphically the plot of the estimated wood volume to DBH growth curve as it passes through the observed data points.

Figure 3.5 Estimated Wood Volume to DBH Growth Curve



3.6.3 Estimation of the Annual Wood Volume Growth Curve.

The estimation of the annual wood volume growth curve was accomplished by taking the annual DBH points estimated by the annual DBH growth equation and inserting them into the estimated wood volume to DBH growth equation. Figure 3.6 shows the per rai wood volume growth curve that was generated using this method. It also shows the results of decreasing the estimated volume by 25 and 50 percent respectively. The per Rai volume growth curve is based on a plantation with one hundred trees, which is the number of trees expected to remain after the commercial thinning in year five.

Figure 3.6 Estimated Annual Wood Volume Growth Curve