Original article

Direct Use Value of Lat Krathing Forest Plantation, Thailand

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ABSTRACT

Direct use value is the main benefit on economic value of forest plantations that is an important for decision-making in management and investment. This research purpose for the direct use value in the 20,422.04 rais at Lat Krathing forest plantation (LKFP) area in Chacheongsao province, Thailand. There were stumpage values, agroforestry system, non-timber forest products and research benefit. Different methods were used to calculate each purpose of the direct use value. The market price method were used for calculated stumpage values, agroforestry system and non-timber forest products, and the individual travel cost method was used for calculated the research benefit. The stumpage values, agroforestry system and non-timber forest products values were 167,044,876 Baht per year, 86,336,609 Baht per year and 306,742 Baht per year, respectively. The research benefit value was 224,276 Baht per year. Therefore, the total direct use value of the LKFP in 2017 was 253,912,503 Baht per year.

Key words: direct use value, individual travel cost method, Lat Krathing forest plantation, market price method, stumpage value.

INTRODUCTION

Forest plantations are increasingly providing both use and non-use benefits similar to the goods and services derived from natural forests, and mosaic forests in agricultural land use are also increasing (Sloan and Sayer, 2015). In Thailand, the Forest Industry Organization (FIO) is a state enterprise established in 1947 and is involved in reforestation since 1967, by operated the forest village system that planted teak (*Tectona grandis* Linn.f.) at Thungkwain forest plantation, Mae-Mye forest plantation, Mae-Moh forest plantation, Mae-Jang forest plantation, Khunmaekhummee forest plantation and Khaokrayang forest plantation in the northern region. Later, the FIO planted other species such as rubber (*Hevea brasiliensis* Muell. Arg.), eucalyptus (*Eucalyptus* spp.), and acacia (*Acacia* spp.) in the other part of Thailand. In 2016, the FIO was responsible for approximately 1,158,000 rais of total plantation areas (Forest Industry Organization [FIO], 2016).

The Lat Krathing forest plantation (LKFP) of FIO is located at Chacheongsao province in the Eastern region of Thailand. In 2017, had an area of 20,422.04 rais that included 13,942.98 rais of production forest area consisting of 8,231.62 rais of various commercial standing tree species and 5,711.36 rais of agroforestry area. There were also 597.68 rais of conservation forest area. Other than, 5,881.38 rais of other land uses, such as offices, nurseries, pools, patrol roads and space area.

Economic value, including the use and non-use value, is a tool urgently needed for decision-making in operational land use planning and investment with regard to appropriate future activities, and also to provide more reliable information on the environmental, social and economic value. The LKFP had many important economic value purposes in the production and conservation areas, such as timber, non-timber forest products (NTFPs), research benefits, and carbon sequestration. This research focuses on the direct use value, which is the main benefit of economic value of the LKFP in 2017. This will form the base information needed for comparison with the direct use value in the future. The results of this comparison could be used as the project successful indicator and the decision-making about forest plantation management and investment in the future.

MATERIALS AND METHODS

Study area

The LKFP is a rehabilitated site located in Lat Krathing sub-district, Sanam Chai Khet district, Chacheongsao province, Thailand. It is about 145 kilometers far from Bangkok. Reforestation

operations begun in 1968 in Kwae rabom-siyad national forest reserve with permission in the Royal Forest Department and under the supervision of Thai Plywood Company Limited. The LKFP area of 20,422.04 rais consists of various land uses, including 13,942.98 rais of production forest (mainly eucalyptus, teak, rubber, and acacia), 587.68 rais of conservation forest and 5,881.38 rais of other uses such as offices, nurseries, pools, patrol roads and space area (Lat Krathing forest plantation [LKFP], 2016) (Figure 1).

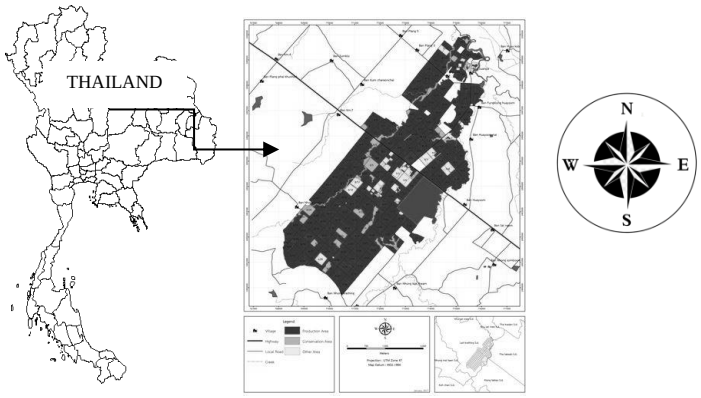

Figure 1 Location of Lat Krathing forest plantation (47P 775911E, 1498303N).
Source: LKFP (2016)

Material

The materials used in this study included a camera, chainsaw, computer, diameter tape, distance measuring tape, Haglof Vertex IV hypsometer, knife, pruning scissor, weighing scale, tally sheet for merchantable timber of forest plantation inventory, tally sheet for merchantable teak of forest plantation inventory and questionnaires for interviewed researcher and local people.

Methods

This research identified four types of direct use value characteristics, namely, stumpage values, agroforestry activity, NTFPs harvesting and research benefit.

Field survey

1. This research considered many methods to insight the basic information of each purpose of the direct use value in the 13,942.67 rais of the production forest area.

1.1 Stumpage value was determined by using the forest inventory technique that depended on the type of tree species.

1.1.1 *Eucalyptus* spp., *Acacia* spp. and other species (except *Tectona grandis* Linn.f.). A systematic sampling method based on the planted rows was used. In surveying, this study used systematic random sampling with 10 % of sampling intensity, with a random starting from row selected the first 10 rows. The first sample was row number 5 from the production forest area boundary and the selection continued to rows 15, 25, 35, until the end of the other side of the forest. Tree data collected consisted of survival rate, girth at breast height (GBH), and total height (H_t) of each tree in each sample row (LKFP, 2016).

1.1.2 *Tectona grandis* Linn.f.. The line plot system with 1.25 % sampling intensity was used. Circular sample plots of radius 12.62 m (or 500 m^2) were placed 200 m apart in a line from the baseline and cruise line. The tree GBH and H_t in each sampling plot were recorded (LKFP, 2016).

1.1.3 Harvesting cost was determined by interviewing the forest plantation manager regarding wage, transportation and other costs to harvest the timber and wooden tips.

1.2 In the agroforestry area of the production forest area, the method of Krejcie and Morgan (1970) was used. This research used a designed questionnaire ~~to~~ and interviewed 113 household heads and collected data, included their profiles, agroforestry pattern, area, planted cost, yield, price, income, harvesting cost, and harvesting pattern.

2. The individual travel cost method (ITCM) was used to direct interviewed four researchers who went to the LKFP in 2017. The designed questionnaire consisted of two parts and gathered general information of the researchers and the research travelling cost in the LKFP in 2017, including number of the researcher, research day, vehicle expenditure, food expenditure, accommodation cost, research tools and material expenses.

3. Local people interview considered 4,026 household heads from 11 villages around the LKFP and used the method of Yamane (1967). About 390 of household heads were interviewed.

3.1 General information about local people were collected. This included personal information such as the respondent's name, and demographic and other background information such as age, gender, education, status in the household, main occupation, income, expenditure, member in family, family settlements, future migration requirements, land holding status, participated in forest conservation activities, and training in forest resource conservation.

3.2 Information about NTFPs harvesting in the LKFP was collected, including type of NTFPs, harvesting time, harvesting frequency, yield, price, and harvesting costs.

Data analysis

1. Stumpage value, which included timber and wooden tips, was determined by using the market value method.

1.1 Allometric models were used to calculate merchantable fresh weight (MFW), merchantable volume (MV) and wooden tip fresh weight (WFW) in each tree (Table 1).

Table 1 The allometric models for timber and wooden tip estimation in the LKFP.

Type of species	Equation	R^2
Timber		
- *Acacia* spp.[1]	- $MFW = -55.977 + 0.099\ G^2$	0.98
- *Eucalyptus camaldulensis* Dehnh.[2]	- $MFW = 0.081(D^2)^{1.4843}$	0.94
- *Eucalyptus urophylla* S.T.Blake[2]	- $MFW = 0.689(D^2)^{1.0707}$	0.99
- *Tectona grandis* Linn.f.[3]	- $MV = -0.197 + 0.005G + 0.008M_L$	0.94
- Other species[4]	- $MV = 0.000084\ (D^2H)^{0.9016}$	0.99
Wooden tip		
- *Acacia* spp.[1]	- $WFW = 3.435 + 0.000179\ G^2H$	0.98
- *Eucalyptus camaldulensis* Dehnh.[2]	- $WFW = 0.007(D^2)^{1.4843}$	0.94
- *Eucalyptus urophylla* S.T.Blake[2]	- $WFW = 0.058(D^2)^{1.0707}$	0.99

Remarks: MFW = Merchantable fresh weight (kg), MV = Merchantable volume (m^3)
WFW = Wooden tip fresh weight (kg), G = Girth at breast height (cm)
D = Diameter at breast height (cm), M_L = Merchantable length (m)
Sources: [1]From this research, [2]Chansrikong (2017), [3]FIO (n.d.), [4]Viriyabuncha *et al*. (2005)

1.2 Total MFW, MV and WFW were calculated by converting the sample tree values to a total for each species. Then, the stumpage value (SV) was determined using Equation 1 (Awang Noor *et al*., 2007).

$$SV = \sum_{j=1}^{N} Q_j(P_{Mj} - C_j - M_j) \quad (1)$$

where SV = Stumpage value (Baht)
Q_j = Total yield in each species (ton or m^3)
P_{Mj} = Market price (Baht/ton or m^3)
C_j = Harvesting cost (Baht/ton or m^3)
M_j = Margin of profit and risk (22.5 % of C_j) (Baht/ton or m^3)
J = 1, 2, 3 that are 1= MFW, 2=MV and 3=WFW

2. Agroforestry system value was done as follows.

2.1 Timber and wooden tip value was determined as the stumpage values by using Equation 1.

2.2 The value of crops was calculated by using Equation 2 (Awang Noor *et al*.,2007)

$$V_{crop} = \sum_{i=1}^{N} \frac{[Q_{Ci}(P_{Mi} - C_{Pi} - C_{Hi})] * N_P}{N_S} \quad (2)$$

where V_{crop} = Value of crops (Baht)
Q_{Ci} = Yield of crops (ton)
P_{Mi} = Market price of crops (Baht/ton)
C_{Pi} = Planting cost (Baht/ton),
C_{Hi} = Harvesting cost (Baht/ton)
N_S = Number of sample (rai)
N_P = Population size (rai), i = 1,2 that are 1=cassava and 2=pineapple

2.3 Agroforestry system value in the production forest plantation area was determined as the sum of the stumpage value and the value of crops (Equation 3).

$$V_{AGRO} = SV + V_{crop} \quad (3)$$

where V_{AGRO} = Agroforestry system value (Baht)

3. The market value method was used to calculate the value of NTFPs by using Equation 4 (Bann, 1998).

$$V_{NTFP} = \sum_{i=1}^{N} \frac{Q_{Ni}\,(P_{Ni}-C_{Ni})*N_P}{N_S} \quad (4)$$

where V_{NTFP} = Value of NTFPs (Baht)
Q_{Ni} = Yield of NTFPs (kg)
P_{Ni} = Market price of NTFPs (Baht/kg)
i, N = Type of NTFPs (1, 2, 3… N)
C_{Ni} = NTFPs harvesting and time opportunity cost (Baht/kg)
N_P = Population size (household head)
N_S = Number of samples (household head)

4. The ITCM based on scientific expenditures within the LKFP was used to calculate the value of research benefit by using Equation 5 (Dixon and Sherman, 1990).

$$V_{RE} = \sum_{i=1}^{N} Veh_i+Food_i+Acc_i+Mat_i+Op_i+Work_i \quad (5)$$

where V_{RE} = Value of research benefit in 2017 (Baht)
Veh_i = Vehicle cost (Baht)
$Food_i$ = Food cost (Baht)
Acc_i = Accommodation cost (Baht)
Mat_i = Material cost (Baht)
Op_i = Time opportunity cost (Baht)
$Work_i$ = Worker cost (Baht)
i, N = Researcher (1, 2, 3…N)

5. The direct use value of the LKFP in 2017 was calculated using Equation 6.

$$V_{DU} = SV + V_{AGRO} + V_{NTFP} + V_{RE} \quad (6)$$

where V_{DU} = Direct use value in 2017 (Baht)

RESULTS AND DISCUSSION

Stumpage values

1. The total MFW of *Acacia spp.*, *E. camaldulensis* Dehnh. and *E. urophylla* S.T.Blake were 129,099.03 tons, 22,115.37 tons and 4,147.01 tons, respectively. The total WFW of *Acacia spp.*, *E. camaldulensis* Dehnh. and *E. urophylla* S.T.Blake were 9,553.29 tons, 1,901.92 tons and 348.35 tons, respectively. The total MV of *T. grandis* Linn.f. and other species were 4,207.60 m^3 and 3,730.19 m^3, respectively (Table 2).

Table 2 The estimation of MFW, WFW and MV in the production forest area (excluding the agroforestry area).

Species	Age (year)	Area (rai)	MFW (ton)	WFW (ton)	MV (m^3)
Acacia spp.	1-32	4,863.98	129,099.03	9,553.29	-
E. camaldulensis Dehnh.	11-32	894.89	22,115.37	1,901.92	-
E. urophylla S.T.Blake	10-29	209.47	4,147.01	348.35	-
T. grandis Linn.f.	1-24	1,495.43	-	-	4,207.60
Other species	3-46	517.73	-	-	3,730.19
Total		**7,981.50**	**155,361.41**	**11,803.56**	**7,937.79**

2. The merchantable timber value of *Acacia* spp., *E. camaldulensis* Dehnh., *E. urophylla* S.T.Blake, *T. grandis* Linn.f. and other species were 98,106,477 Baht, 28,746,551 Baht, 5,391,758 Baht, 29,213,225 Baht and 1,863,828 Baht, respectively. The wooden tip values of *Acacia* spp., *E. camaldulensis* Dehnh. and *E. urophylla* S.T.Blake were 3,010,804 Baht , 602,261 Baht and 109,972 Baht, respectively. Therefore, the value of timber, wooden tip and the stumpage value in the LKFP production forest area (except in agroforestry area) were 163,321 Baht, 839, 3,723,037 Baht and 167,044,876 Baht, respectively (Table 3).

This research found that the proportion of WFW compared MFW in *Acacia* spp., *Eucalyptus camaldulensis* Dehnh. and *Eucalyptus urophylla* S.T.Blake were 7.40 percent, 8.60 percent and 8.40 percent, respectively. The value of WFW compared MFW in *Acacia* spp., *Eucalyptus camaldulensis* Dehnh. and *Eucalyptus urophylla* S.T.Blake were 3.07 percent, 2.10 percent and 2.04 percent, respectively. This is because the wooden tip harvesting requires additional expenses compared to the timber harvesting.

Table 3 The estimation of SV in the LKFP production forest area (excluding the agroforestry area).

Type of species	Area (rai)	Unit	Yield (unit)	Stumpage Price (Baht/unit)	Harvesting cost (Baht/unit)	Margin (Baht/unit)	SV (Baht)
Timber							
- *Acacia* spp.	4,863.98	ton	129,099.03	760	-[1]	-	98,106,477
- *E. camaldulensis*	894.89	ton	22,115.37	1,300	-[1]	-	28,746,551
- *E. urophylla* S.T.Blake	209.47	ton	4,147.01	1,300	-[1]	-	5,391,758
- *T. grandis* Linn.f.	1,495.43	m^3	4,207.60	8,300	1100	248	29,213,225
- Other species	517.73	m^3	3,730.19	500	-[1]	-	1,863,828
Total of timber	7,981.50						163,321,839
Wooden tip							
- *Acacia spp.*	4,863.98	ton	9,553.29	500	150	34	3,010,804
- *E. camaldulensis*	894.89	ton	1,901.92	500	150	34	602,261
- *E. urophylla* S.T.Blake	209.47	ton	348.35	500	150	34	109,972
Total of wooden tip							3,723,037
Total	**7,981.50**						**167,044,876**

Remark: [1]The customers paid for this harvesting cost.

Agroforestry system

The LKFP had 5,711.36 rais in the agroforestry area. There were 4,029.51 rais of *E. camaldulensis* Dehnh. and 1,472.13 rais of *E. urophylla* S.T.Blake, mixed with together with cassava (*Manihot esculenta* Crantz). As well, there were 209.72 rais of *H. brasiliensis* Mull.Arg. mixed with pineapples (*Ananas comosus* (L.) Merr.).

1. Stumpage values.

1.1 The total MFW of *E. camaldulensis* Dehnh. and *E. urophylla* S.T.Blake were 53,507.66 tons and 7,809.50 tons, respectively, and the total WFW of *E. camaldulensis* Dehnh. and *E. urophylla* S.T.Blake were 4,601.66 tons and 656.00 tons, respectively (Table 4).

1.2 The merchantable timber value of *E. camaldulensis* Dehnh. and *E. urophylla* S.T.Blake were 69,565,461 Baht and 10,142,976 Baht, respectively. The wooden tip values of *E. camaldulensis* Dehnh. and *E. urophylla* S.T.Blake were 1,450,624 Baht and 209,042 Baht, respectively. Thus, the value of timber, wooden tip and stumpage value in the agroforestry area were 79,708,437 Baht, 1,659,666 Baht and 81,368,103 Baht, respectively (Table 5).

2. The value of crops in the LKFP agroforestry area, such as *M. esculenta* Crantz in 4,029.51 rais of, *E. camaldulensis* Dehnh. and 1,472.13 rais of *E. urophylla* S.T.Blake plots, were 3,578,205 Baht and 1,307,252 Baht, respectively, and *Ananas comosus* (L.) Merr in 209.72 rais of *H. brasiliensis* Mull.Arg. plots was 83,049 Baht. Therefore, the value of crop in the agroforestry area was 4,968,506 Baht (Table 6).

3. The value of agroforestry system in the production forest area was 86,336,609 Baht.

Table 4 The estimation of the total merchantable timber and wooden tip in the agroforestry area.

Species	Age (year)	Area (rai)	MFW (ton)	WFW (ton)
E. camaldulensis Dehnh.	2-10	4,029.51	53,507.66	4,601.66
E. urophylla S.T.Blake	1-9	1,472.13	7,809.50	656.00
Total		**5,501.64**	**61,317.16**	**5,257.66**

Table 5 The estimation of stumpage values (SV) in the LKFP agroforestry area.

Type of species	Area (hectare)	Yield (ton)	Stumpage Price (Baht/ton)	Harvesting cost (Baht/ton)	Margin (Baht/ton)	SV (Baht)
Timber						
- *E. camaldulensis* Dehnh.	4,029.51	53,507.66	1,300	-[1]	-	69,565,461
- *E. urophylla* S.T.Blake	1,472.13	7,809.50	1,300	-[1]	-	10,142,976
Total of timber	5,501.64	61,317.16				79,708,437
Wooden tip						
- *E. camaldulensis* Dehnh.	4,029.51	4,601.66	500	150	34	1,450,624
- *E. urophylla* S.T.Blake	1,472.13	656.00	500	150	34	209,042
Total of wooden tip	5,501.64	5,257.66				1,659,666
Total	**5,501.64**					**81,368,103**

Remark: [1]The customers paid for this harvesting cost.

Table 6 The estimation of crop values in the LKFP agroforestry area**.**

Main species	Area (hectare)	Crop	Yield (ton)	Price of crop (Baht/ton)	Planting cost (Baht/ton)	Harvesting cost (Baht/ton)	Value of crops (Baht)
E. camaldulensis Dehnh.	4,029.51	C[1]	8,099.32	1,926	1,769	1,214	3,578,205
E. urophylla S.T.Blake	1,472.13	C[1]	2,958.98	1,926	1,769	1,214	1,307,252
H. brasiliensis Mull.Arg.	209.72	C[2]	419.44	2,000	2,500	1,104	83,049
Total	**5,711.36**						**4,968,506**

Remark: [1]*Manihot esculenta* Crantz, [2]*Ananas comosus* (L.) Merr.

NTFPs harvesting

NTFPs gathering interviews found that the local people gathered NTFPs, which included fuel wood, bamboo shoots, fruits, vegetables, mushrooms, plant tubers, insects, small animals and herbs.

The NTFPs gathering, the benefit of NTFPs, the NTFPs gathering cost and the average value of NTFPs gathering were 62,634 kg, 45,791 Baht, 16,073 Baht and 76.19 Baht per household, respectively and the value of NTFPs harvesting by 4,026 households was 306,742 Baht (Table 7).

Table 7 The estimation of the value of NTFPs (V_{NTFP}) in 2017.

Type	NTFP gathering (kg)	Benefit of NTFPs (Baht)	Harvesting Cost (Baht)	V_{NTFP} (Baht/household)	V_{NTFP} (Baht)
Fuel wood	62,246	31,123	7,429	60.75	244,580
Bamboo shoots	91	1,820	1,234	1.50	6,039
Fruits	11	250	127	0.32	1,288
Vegetables	140	5,483	3,479	5.14	20,694
Mushrooms	89	4,790	2,866	4.93	19,848
Plant tubers	20	600	246	0.91	3,664
Insects	1	120	33	0.22	886
Small animals	11	1,100	420	1.74	7,005
Herbs	25	505	239	0.68	2,738
Total	**62,634**	**45,791**	**16,073**	**76.19**	**306,742**

Research benefit.

The vehicle expense, food expense, accommodation expense, material expense, time opportunity cost, worker employment and the research benefit, based on four researcher groups who went to the LKFP in 2017, were 34,100 Baht, 26,500 Baht, 4,000 Baht, 15,063 Baht, 93,175 Baht, 51,438 Baht and 224,276 Baht, respectively (Table 8).

According to the entire values of the stumpage values, agroforestry system, NTFPs harvesting and research benefit, this research can be calculated the direct use value of the LKFP in 2017 was 253,912,503 Baht.

Most of the direct use value in the LKFP is the stumpage values (99.79 percent) which is in the production forest area (65.79 percent) and agroforestry area (34.00 percent). The NTFPs gathering and the research benefit were a small proportion of the direct use value, only 0.12 percent and 0.09 percent, respectively.

Table 8 The estimation of the value of research benefit (V_{RE}).

List	Unit	Researcher group				Total
		1st	2nd	3rd	4th	
Number of trip	(time/year)	1	6	2	2	11
Research day	(day)	2	64	4	10	80
Number of researchers	(person)	5	1	5	3	14
Vehicle expense	(Baht)	8,000	11,800	4,000	10,300	34,100
Food expense	(Baht)	2,000	9,300	8,000	7,200	26,500
Accommodation expense	(Baht)	4,000	-	-	-	4,000
Material expense	(Baht)	-	1,863	6,000	7,200	15,063
Time opportunity cost	(Baht)	17,675	72,000	1,500	2,000	93,175
Worker employment	(Baht)	-	7,500	16,665	27,273	51,438
Total		**31,675**	**102,463**	**36,165**	**53,973**	**224,276**

CONCLUSION

This research calculated the direct use value of the LKFP in 2017 was 253,912,503 Baht per year including.

1. The stumpage value in the 7,981.50 rais of the production area (except in the agroforestry area) in 2017, calculated by using the market price method was 167,044,876 Baht per year.

2., The value of agroforestry system in the production forest area in 5,711.36 rais of the agroforestry area, calculated by using the market price method was 86,336,609 Baht per year.

3. The value of NTFPs gathering in 2017, calculated by using the market price method was 306,742 Baht per year.

4. The value of research benefit in 2017, calculated by using the individual travel cost method was 224,276 Baht per year.

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