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Estimating benefits of forest ecosystem service to support payments for ecosystem services in Mae Sa Watershed, Chiang Mai, Thailand

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Abstract Payments for ecosystem services (PES) is a tool for managing the natural resources and environment. It uses for forest resources reservation or improvement for such services by upstream villagers from their conservation activities such as forest plantation, forest fire protection, check dam building and living weir establishment. These ecosystem services render benefits to all stakeholders that should return to support upstream village communities under the beneficiaries-pay concept of PES. Mae Sa watershed is a popular tourist attraction in Chiang Mai with the presence of many tourism activities, resorts, coffee shops and restaurants. All of the tourism businesses benefit from the forests' beautiful scenery and pleasant atmosphere. Moreover, a direct benefit of the forest is carbon sequestration regarded as climate regulating services. This research finding evaluated the economic value from conservation activities in Mae Sa watershed in terms of the benefits of forest ecosystem services for recreation and climate regulating. The results revealed that the value of recreation benefits were 19,558,574 baht/year which was willingness to pay at 44.70 and 37.90 baht/person/time. Besides, there were four independent variables that influenced the willingness of tourists to pay, namely: income per month, the frequency of visits, the awareness of management problems of natural resources, environment and starting bid prices. The value of carbon sequestration from reforestation was analyzed from aboveground biomass, price of carbon credits of forest and land use from the Forest Trends' Ecosystem Marketplace. The value would continue to increase in every year. Thus, it concluded that the benefits of forest ecosystem services would greater than the cost of conservation activities.

Keywords: Ecosystem services valuation, double bound close – ended, contingent valuation method, carbon sequestration, carbon credit

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Introduction

Payments for ecosystem services will lead to more efficiency of natural resource utilization by economic incentives. Those people protecting and enhancing the ecosystem service provision will be recognized as ecosystem service providers who make a positive impact on the people living outside the area (beneficiaries) or users of the ecosystem services (Steiner *et al*., 2000). In return, the service users provide payments to the service providers as incentives to manage their land or natural resources for the purpose of enhancing the ecosystem services. PES is a motivational tool for local communities to protect and restore soil, water, forests and ecosystem by using economic incentives (Pagiola, 2008 and Wunder, 2007).

The forest is a complex ecological system that provides numerous ecosystem services such as goods (timber, food), ecological function (carbon sequestration, air and water purification) and cultural benefits (recreation). The satellite image translation by the Royal Forest Department (2016) found that forest covered area in northern Thailand was 56,379,409 rai, decreasing from 1973 to 14,617,466 rai or decreasing 0.34% per year (Royal Forest Department, 2016).

In Mae Sa watershed, forested areas continue to decline under the rapidly expanding economic activities especially in agricultural areas and tourism businesses. Between 2010 and 2015, the natural forest area in the Mae Sa watershed disappeared by 161 rai per year, but the reforested land increased only 40 rai per year. Hence, the government has tried to promote and support the conservation activities, but the outcomes were not fully effective. Recently, payments for the ecosystem services scheme have been implemented in this area by the United States Agency for International Development's: Lowering Emissions in Asia's Forests (USAID-LEAF) in 2011 – 2015, and Integrated Community-based Forest and Catchment Management through an Ecosystem Service Approach (CBFCM) in 2012 - 2017 (Report of Ecological Assessment by Faculty of Forestry, Kasetsart University, 2016).

Mae Sa watershed is a tourist attraction that visitors to Chiang Mai often take time to visit because this area has abundant forest and beautiful scenery as recreational services. There are many forest activities such as relaxing, viewing the scenery, hiking, zip line adventure and ATV travel cars. Moreover, there are a lot of tourism businesses that are expanding in growth as the number of tourists reached 437,552 persons in 2016. Bountiful forests and beautiful scenery are the benefits from the upstream villages’ conservation activities that require a cost and the tourists receive the external benefits. Thus, they should pay or support the upstream villages by the PES payment mechanism to increase their conservation activities similar to the visitors to the Lake District National Park in England. The visitors donate money to promote landscape management via participating in local businesses, providing a mechanism for tourists who get direct benefits from the natural environment (Department for Environment, Food and Rural Affairs, 2013).

Moreover, the direct benefits of forests are carbon sequestration from the upstream village reforestation as climate regulating services that can be evaluated for its economic value based on the price of carbon credit of forest and land use from the Forest Trends’ Ecosystem Marketplace. This study intended to evaluate the benefits of forest ecosystem services accrued from land cover changes consequential to conservation activities in terms of economic value of carbon sequestration and recreation. The values are evaluated on the grounds of the market price technique and the tourists' willingness to pay for conserving natural resources, environment and landscape.

Materials and methods

The Mae Sa watershed is located in Mae Rim District, Chiang Mai, Thailand. It covers a total area of 142.30 square kilometers or 87,113 rai (1 hectare = 6.25 rai) and can be divided into four parts as follows: forests 53,336.81 rai or 61.23 %, agriculture 19,403.44 rai or 22.27 %, residential area 12,906 rai or 14.82 % and others 1,466.44 rai or 1.68 % (Land Development Department, 2016 and Regional Environment Office 1, 2016). The watershed is comprised of upstream and downstream areas. There are several villages in the upstream portion where local villagers are considered as ecosystem service providers in this study. The research was carried out with activities for conserving the natural resources and environment. The number of tourists in Mae Sa watershed in 2016 was 437,552, and these visitors were considered as ecosystem service users.

The data were collected by two methods: 1) questionnaire for assessing tourists' willingness to pay for conserving natural resources, environment and landscape and 2) field survey of tree growth rate for valuating carbon sequestration.

This study implemented four technical approaches including: 1) Contingent valuation method using the double bound close-ended method to evaluate the willingness to pay, which involves directly asking people how much they would pay to prevent loss of, or enhance an ecosystem service (Federal Ministry for Economic Cooperation and Development: BMZ, 2012). 2) The factors affecting the willingness to pay by using the censored regression model in the SAS program. 3) Carbon sequestration equation by allometric equations of other tree species for a mixed deciduous forest (Ogawa, 1965). And 4) Market price technique that involves the money paid for ecosystem goods and services that are traded in commercial markets (Federal Ministry for Economic Cooperation and Development: BMZ, 2012).

The number of tourists visiting Mae Sa watershed in 2016 was 437,552 (Suthep - Pui National Park 3, Mae Sa waterfall, and Mon Cham Nong Hoi Royal Project, 2016). The required number of samples in this research was calculated by using Taro Yamane (Yamane, 1967) formula with 95% confidence level and thus it became 400.

The pretest open – ended questionnaire was used in 30 samples to find out the starting prices. The starting prices will make the decision of respondents clear, reducing the variance of parameters and determining the willingness to pay accurately. It was found that 12 samples were willing to pay 20 baht for supporting this hypothetical market while 18 samples were not willing to pay. In this research, the starting prices of 10, 20, 30 and 40 were used. Each proposed amount of money in collecting the data was conducted with 115 samples. With the collected data, the censored regression model in SAS program was applied for analysis and evaluation of the willingness to pay and the determinants of willingness to pay of tourists.

The data was collected by using the double bound closed – ended questionnaire for the primary model as follows;

$$\text{Model}\ (Lower_i, Upper_i) = f\,(G_i, A_i, Nat_i, Edu_i, Occ_i, I_i, Hb_i, Hf_i, Sat_i, Act_i, Pl_i, Awa_i, B_{xi})$$

Where: $Lower_i$ is the lower bound value of willingness to pay of the respondents i, $Upper_i$ is the upper bound value of willingness to pay of the respondents i, G_i is the gender of tourists (1 if male, 0 if female), A_i is the age of tourists (years), Nat_i is the nationality of tourists (1 if not Thai, 0 if Thai), Edu_i is the educational level (unit: years), Occ_i is the occupation of tourists (1 if routine work, 0 if freelance), I_i is the tourists' income per month (baht), Hb_i is travel experience in this area (1 if having visited before, 0 if never before), Hf_i is the frequency of visit in this area per year (times), Sat_i is the satisfaction score of visiting this area (score), Act_i is the number of activities done in this area (number), Pl_i is the opinion on the state of natural resources and environment in this area (1 if bountiful, 0 if not), Awa_i is the awareness of management problems of natural resources and environment (score), B_{xi} is the starting bids/prices of 10, 20, 30 and 40 baht/time/person, i is a sample of i.

This study used the data of carbon sequestration from the growth rate of reforestation in Mae Sa watershed between 2013 and 2017. The growth rates were collected from the perimeter (diameter at breast height) and height of ten samples per rai in each age of the trees. The forest plantation in the Mae Sa watershed was established by seven upstream villages. The number of trees planted per rai was initially 400 but the survival rate might be 60 – 70%. Thus, this study used 280 trees per rai to estimate the aboveground biomass.

Planting new forests can help remove carbon dioxide from the atmosphere as young trees absorb carbon dioxide while they are growing and store it throughout their lifetime. In the past few decades, the world's forests have absorbed as much as 30% of annual global anthropogenic CO2 emissions (Bellassen and Luyssert, 2014). Reforestation is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources on land that was forested, but that has been converted to non-forested land (Neeff *et al.*, 2006).

Tree biomass was estimated using allometric equations of other tree species for mixed deciduous forest (Ogawa, 1965).

$$W_s = 0.0396\ (DBH^2 \times H)^{0.9326}$$
$$W_b = 0.003487\ (DBH^2 \times H)^{1.027}$$
$$\frac{1}{W_l} = \frac{28}{W_s + W_b} + 0.025$$

Where W_s, W_b and W_l are the dry weight of the stem, branches and leaves, respectively, of a tree (kg/individual tree).

Aboveground carbon stocks were calculated by multiplying amount of aboveground biomass (Dry matter stem, branches, and leaves) with carbon fractions (Japan Weather Association, 2014; Prasertpong, 2016).

Aboveground carbon stocks = aboveground biomass x 0.5

Where 0.5 is carbon fraction of vegetation biomass (kg/individual tree)

GHG emission corresponds to carbon stocks in vegetation originally grown on the afforestation land. It can be calculated by multiplying with carbon stocks of biomass (dry matter) (Lueangjam, 2008; Japan Weather Association, 2014).

Carbon sequestration = carbon stocks of biomass x 44/12

Where 44/12 is CO_2 conversion factor of carbon. 44/12 is the carbon volume containing in wood, derived from photosynthesis of plants. C has a molecular weight of 12, and O has a molecular weight of 16. As O has two molecular weights combined equals to 32, the carbon dioxide has a molecular weight of 44 (Lueangjam, 2008).

The value of carbon sequestration was based on the price of carbon credit of forest and land use from Forest Trends' Ecosystem Marketplace at 5.10 USD per ton CO_2 (http://www.forest-trends.org/dir/em, 2017), and the exchange rate between Thai Baht and USD was 33.32 baht per 1 USD.

Results

Benefits of recreation

All expected factors related to the willingness to pay were used to correlate all independent variables by using the correlation method and the multicollinearity test. From this, the multicollinearity problems were found since the independent variables in the equation had a high statistical correlation. Hence, the stepwise method was used to solve the problem by selecting the high correlation coefficients and then taking them out. The final correlation of all independent variables was analyzed.

The final model was statistically significant and there was no multicollinearity problem as follows;

$$\text{Model (Lower, Upper)} = f\,(B_{xi}, I_i, Hf_i, Sat_i, Act_i, Awa_i)$$

The starting prices of 10, 20, 30 and 40 baht/person/time were used in this study. The probability situations were from the sample group of 460 tourists. It was found that the tourists who were willing to pay for starting prices and the second prices was 53.0% and the percentage of the starting bid prices increased to 20, 30 and 40 baht, being 50.0%, 33.9% and 19.1%, respectively (Table.1).

Table 1. Probability of the starting prices

Starting price (baht/person/time)	Possible situation (percentage)			
	YY	YN	NY	NN
10	53.0	33.0	0.9	13.0
20	50.4	25.2	9.6	14.8
30	33.9	23.5	16.5	26.1
40	19.1	26.1	19.1	35.7

From the questionnaire, the real value of the willingness to pay could not be found, but the lower bound and upper bound values can be specified. The willingness to pay (WTP) is only a random variable defined by the vector value of the independent variable based on the probability model.

In the case of the starting price of 10 baht, the upper bound of willing to pay for both times Pr (YY) was the maximum WTP and its lower bound was 10 baht (53.0%). The upper bound of willing to pay at the first time but not willing to pay at the second time Pr (YN) was 20 baht and its lower bound was 10 baht

(33.0%). The upper bound of not willing to pay at the first time but willing to pay at the second time Pr (NY) was 10 baht and its lower bound was 5 baht.

The upper and lower bounds of not willing to pay for both times Pr (NN) were 5 and 0 baht (13.0%), respectively.

The maximum willingness to pay (WTP) at the upper bound was used to analyze the willingness to pay in terms of the probability distribution. It was found that the suitable probability distribution was log - normal because it was the maximum log – likelihood (-460.3437003) when the model had no independent variables (LnL0). Thus, a log-normal probability distribution was used to analyze the willingness to pay.

The values of log – likelihood of no independent variable equation (LnL0) and log – likelihood of independent variable equation (LnL1) were used to evaluate the Pseudo R2 value. In this study, the Pseudo R2 value was 26.75, meaning that independent variables could explain the tourists' willingness to pay for conserving natural resources, environment and landscape in Mae Sa watershed with 26.75%, while the remaining 73.25% was influenced by the independent variables outside the scope of this study. Then, mean and median of willingness to pay were calculated to be 44.70 and 37.90 baht/person/time, respectively (Table 2).

The total tourists' willingness to pay for conserving natural resources, environment and landscape in Mae Sa watershed was calculated by multiplying the number of tourists per year (437,552 persons/year) and the mean of the willingness to pay (44.70 baht/person), which turned out to be 19,558,574 baht/year. This value reflected that the tourists gave precedence to the natural resources and environmental problems in this area where they came to relax, travel, adventure, dine and drink.

Factors affecting the willingness to pay for conserving natural resources, environment and landscape were analyzed using Lifereg Procedure in SAS program. On the criteria of significance at 95 percent and P – values less than 0.1, four independent variables were found to influence the willingness to pay of tourists, namely: income per month, the frequency of visits, the awareness of management problems of natural resources and environment, and starting bid prices (Table 2).

Benefits of carbon sequestration

The evaluation is averaged the growth in diameter and height of trees, which were planted for reforestation in Mae Sa watershed from 2013 to 2017. The biomass, the carbon retention and the carbon dioxide absorbed were evaluated the value of carbon sequestration. The tree heights in the 1st – 2nd year were less than 130 cm. The total aboveground carbon stock is half of the total aboveground biomass per stem. The tree growth, total biomass, and carbon stock per stem in the 5th year was 7.51 and 3.76 kg, respectively.

Table 2. Estimation results for the contingent valuation

Statistic	Coefficient	P - value
Log – likelihood of no independent variable equation (LnL_0)		-460.3437
Log – likelihood of independent variable equation (LnL_1)		-337.2219
Intercept (β)		3.6349
Scale (σ)		0.5742
Mean WTP		44.6900
Median WTP		37.8979
Pseudo R^2 (%)		26.75
Intercept	2.5161	<.0001
Nationality	0.0032	0.9638
Income per month	0.0028	<.0001
Frequency	-0.0472	0.0149
Satisfaction	0.0327	0.3282
Activity	-0.0279	0.5192
Awareness	0.0361	0.0730
Starting prices: 20	0.0279	<.0001
30	0.0257	<.0001
40	0.0225	<.0001

The carbon sequestration in the 3rd year was 3.60 kg/stem, and 1.09 tons of CO2/rai with the economic value of carbon sequestration of 171.52 baht/rai. In the 5th year, the carbon sequestration became 13.78 kg/stem, and 3.86 tons of CO2/rai with the economic value of carbon sequestration of 655.48 baht/rai.

The reforestation areas in the watershed were gathered from a survey and the CBFCM project (2017). Table 3 showed the reforestation areas in each year during 2013-2017 under the efforts of the villagers in seven upstream villages. The carbon sequestration value was accumulated from the year forest plantation was first established to the present (2017). The accumulated value of 27 rai of forest plantation from 2013 to 2017 is 17,698 baht. Meanwhile, 22 and 36 rai of area reforested in 2014 and 2015, as of 2017, have accumulated a value of 6,782 and 6,175 baht respectively. During a period of 3 – 5 years, the total forested area of 85 rai could generate the total value of carbon sequestration of 30,655 baht. However, the value of carbon sequestration from reforestation in

Mae Sa Watershed increased every year with the age and total biomass of trees (Table 3).

Table 3. Reforestation areas from 2013 to 2017 by upstream villages and value of carbon sequestration of reforestation

Item	2013	2014	2015	2016	2017	Total
Village						
1) Mae Mae	5	2	-	5	-	12
2) Pong Krai	-	-	10	20	-	30
3) Mae Nai	2	-	3	2	2	9
4) Kong Hae	-	-	3	-	2	5
5) Nong Hoi Kao	20	20	20	30	-	90
6) Pang Luang – Bao Teoy	-	-	-	5	10	15
Total area of reforestation (rai)	27	22	36	62	14	161
Aboveground biomass from the year that land was reforested until 2017 (kg)	56,760	21,740	19,760	-	-	98,260
Aboveground Biomass stocks (kg)	28,430	10,900	9,880	-	-	49,210
Carbon sequestration (ton CO2)	104.22	39.82	36.0	-	-	180.04
Value of carbon sequestration (Thai baht)	17,698	6,782	6,175	-	-	30,655

Discussion

The reserch finding presented the ecosystem service valuation from the upstream conservation activities. These values are the partial economic value of forest ecosystem services in Mae Sa watershed, presented in terms of value of recreation benefits and carbon sequestration. The payment from tourists has been implemented in England at Nurture Lakeland (Lake District National Park) (Department for Environment, Food and Rural Affairs, 2013), but not yet in Mae Sa Watershed due to its lack of regulation in PES payment and in the operation of Thai environmental laws on national parks. Moreover, currently there is no co-organization or intermediary to help set up a clear contract for a PES scheme. However, the committee of "The Payment for Ecosystem Services of Mae Ram and Mae Sa Watershed Fund" made a billboard of conservation activities and provided donation boxes for various tourist attractions. Another threat is that the payment depends on the individual's willingness from his/her awareness, so it leads to a free riders problem (Obeng *et al.,* 2018).

The carbon sequestration in Clean Development Mechanism (CDM) for small-scale afforestation and reforestation projects could absorb up to 16,000 tons of CO2/year without limiting the area of reforestation (Thailand Greenhouse Gas Management Organization, 2018). In the Mae Sa watershed, the forest plantation can absorb 3.86 tons of CO2/rai or 3.86 x 3.67 = 14.17 tons of CO2/rai/5 years. Therefore, for carbon sequestration of 16,000 tons of CO2/year, reforestation has to be done 16,000/14.17 = 1,129 rai/5 years or 5,645 rai/year, and that could be a small forest plantation in CDM project. Nevertheless, the long-term CDM-compliant certification ending the credit depends on the agreement and may be 20, 30, 40, 60 years or the period of tree cutting. Even though forest plantation in Mae Sa watershed is possibly difficult to achieve in the CDM project, the economic valuation of carbon sequestration of reforestation can make all stakeholders aware and conserve forested areas (Pagiola, 2008 and Wunder, 2007). Moreover, the value of carbon sequestration from reforestation in the Mae Sa watershed will increase every year with the age and total biomass of trees. According to Bellassen and Luyssert (2014), planting new forests can help remove carbon dioxide from the atmosphere as young trees absorb carbon dioxide while they are growing and store it throughout their lifetime.

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