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# The Valuation of Forest Ecological Services: A Meta-Analysis

**Tiparpa Ratisurakarn**
*School of Development Economics,*
*National Institute of Development Administration, Bangkok, Thailand.*
*Corresponding author: tiparpa.r@hotmail.com*

## Abstract

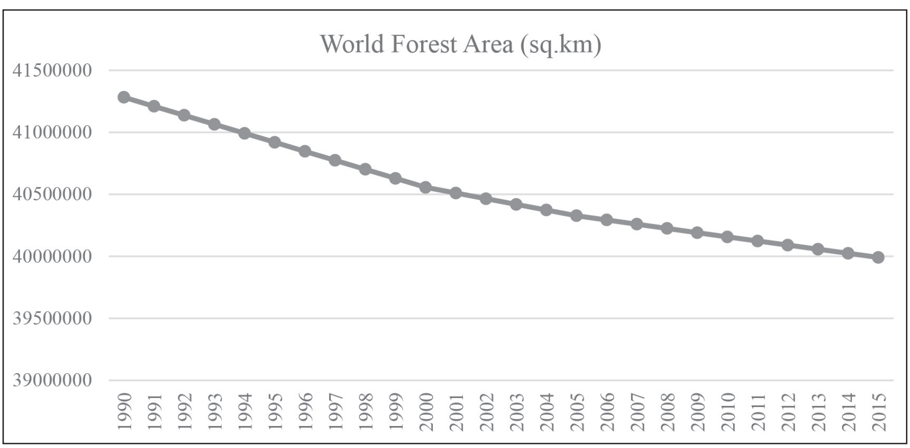
Forests have a significant impact on global ecosystem services. Deforestation continues to be one of the world's biggest problems in terms of environmental degradation. There has been an ongoing debate pitting economic development versus environmental preservation, especially in developing countries. Forest valuation is the usual key to measure the cost-benefit of the forest before making a decision. In this research, a Meta-analysis was conducted using 155 observations from 47 different countries. The mean forest valuation of these observations is $US65.62 per hectare per 1000 person per year (in 2016). The OLS regression results found that forest use values, methodology, and forest types by geographical latitude are statistically significant to forest value. Forest use values have more monetary value over non-use. The results when applied to forest valuation in Thailand, the predicted use value of the Thai evergreen forest conducted by the contingent valuation method is valued around $US23.94 per hectare per 1000 person per year (in 2016).

**Keywords:** Meta-analysis, environmental economics, forest valuation, ecological value, ecosystem services.

## 1. Introduction

Over the past decades, there has been a decline in environmental quality across the globe. Deforestation is one of the contributing factors since forests have a significant influence on ecosystem services. The rate of forest loss has halved over the past thirty years according to the Global Forest Resources Assessment but is still high (Keenan, 2015). High population growth resulted in increasing demand for food, clothes, shelter, and belongings. This naturally leads to a growing lack of supplies which are natural resources throughout the world. High consumer demand is the driving force of land use change. Trees are cut down more and more for timber products, to clear forest for cultivation, farming of livestock, to pave the way for roads, and constructions. In short, while societies become more urbanized, the natural ecosystem becomes more deteriorated (Martinez et al., 2009). High deforestation causes a disruption of the ecological system as evident in the current situation such as climate change, air pollution, loss of biodiversity, flooding, soil erosion, and landslides (Menkhaus and Lober, 1995). The World Bank data as shown in figure 1 displays a continuous decline in the forest area since 1990 (World Bank, 2015).

**Figure 1.** World Forest Area (sq. km)




**Notes:** World forest area (1sq.km=100ha.)
**Source:** Worldbank, 2015

The forest has multiple uses, services, and functions. Forest use can be overlapping and combining its value can be complex. Economists measure forest valuation in terms of forest services, as it reflects on individuals' welfare. There are a few valuation methodologies as well as different forest classification and types. This study will undertake a Meta-Analysis to identify how forest classifications and socio-economic conditions affect forest value estimates.

Currently, there is an increasing number of researches in the field of forest valuation. However, research studies are still limited in developing countries. Many existing research studies conducted forest valuation based on the forest's individual site. Each study has different purposes with different interpretations in terms of methodology and ecological uses. Therefore, policymakers may face a problem of picking which research is best to base their decision on to make a sound policy or to issue a fine for deforestation offenses. It is difficult to judge the appropriate value for each case. Many criticize the same literature as being over-estimates and at the same time, under-estimates whilst some of these errors occurred due to technical mistakes and others may be intended for political reasons.

The data used in this study are based on forest valuation from existing studies all over the world. A meta-regression estimated using the result of combined study sites can provide a more comprehensive set of information to better assist policymakers. Particularly in the form of benefit transfer that can be used in shaping policy context. The concept of a Meta-analysis is to combine original research studies, generalize the results and estimate the relationship between dependent variables and a set of explanatory variables. In this case, forest values from multiple sites are combined to estimate a meta-equation that shows a statistical relationship between forest values and a set of explanatory variables. The study was designed including consideration of each country's land area and population. Therefore, once the value per hectare per person is established the information can readily be used to assist policymakers in decision making.

The contribution of this study will provide overall estimates for different forest types and regions. The first part of this research is to find out what factor influences forest values by estimating a meta-regression. The second part is by using the benefit transfer method, Meta-analysis regression results can provide estimated forest value on the unresearched forest site.

# 2. Literature Review

## 2.1 Meta-Analysis

Policymakers often face a question of how to select researches from an abundant of information when trying to translate researches into social policy. Often there are hundreds of studies, and many approaches the subject from different angles (Mann, 1994).

Meta-analysis is a statistical method used to synthesize the results of multiple studies to provide a quantitative summary (Arnqvist & Wooster, 1995). It is an approach that combines secondary data as research integration by recording its properties and their findings. The re-analysis of primary data could answer a new question with old data or with improved statistical techniques (glass *et al.*, 1981). Randall, Kidder, and Chen (2008) stated that meta-analysis has become the standard methods of searching for general patterns from existing research.

The first paper published on meta-analysis was in 1904 when the statistician Karl Person grouped data from British military tests to conclude that the then-current practice of vaccination against intestinal fever was ineffective (Mann, 1994). Meta-analysis has then been practiced in various discipline since, but mostly for clinical data. There are multiple meta-analysis researches carried out in environmental economic field including hedonic valuation of air pollution (Smith & Huang, 1995); elevated carbon (Cutis & Wang, 1998); carbon forest sink (Kooten, Eagle, Mandley, & Smolak, 2005); assessing the impact of watershed program (Joshi, Jha, Wani, Joshi, & Shiyani, 2005); and estimating value for multi-function agriculture (Randall *et al.*, 2008).

The existing meta-analysis on forest study focuses on either specific type of forest ecosystem services or focus on one continent, or both such as Zanderson and Tol (2009) study focused on forest recreation values in Europe; Shrestha and Loomis (2001) focused on US outdoor recreation use values; Otrachshenko (2014) on passive use value of Mediterranean forest; and Ojea and Martin-Ortega (2015) on watersheds function for tropical forest in South and Central America.

Rosenberger and Loomis (2003) define a meta-regression analysis transfer function as:

$$V_{Pj} = f_s\left(Q_{S\ P_j}, \bar{X}_{S\ P_j}, M_{S\ P_j}\right) \tag{1}$$

The dependent variable, $V_{Pj}$ is the value of a policy site j is a function of data from each study site i. On the right-hand side is a set of explanatory variables where (Q) is a function of quantity or quality variables; (X) is a function of socio-demographic variables such as income, age, or education and site characteristics such as location, and land type; and (M) is methodological variables for each study i.

The model of meta-analysis with a simple OLS regression is:

$$y_i = \alpha + \beta x_i + \varepsilon_i \text{ with } \varepsilon_i = \mu_i + e_i \tag{2}$$

where $y_i$ is the dependent vector i observation, $\alpha$ is a constant, $\beta$ is the coefficient or slope of $x_i$, $x_i$ is the explanatory variable of observation I, and $\varepsilon_i$ represent a random component or error term. The dependent variable can be any values of interest.

One of the main reasons for meta-analysis popularity is that it also reduces statistical errors. Mann (1994) explained in statistic there are two types of error: Type I error conclude that research has found a correlation or effect when one does not exist, and Type II error presume that there is no correlation or effect when one does exist. To avoid Type I error often researchers set the parameters much more cautious that it may miss the link of finding an association or effect. When the result showed less than 5% chance of being from error terms, the 5% is considered the probability of Type I error while Type II error is often overlooked. Therefore, researches that include small numbers of sample size may not pick up on signs of those with lower percentile and reject the hypothesis. Meta-analysis, on the other hand, considered the distribution of all effect sizes, significant or not, so it may pick up on a signal that the individual studies may not be able to pick up.

## 2.2 Economic Valuation Method

The environmental economic valuation method can be categorized into market valuation and the non-market valuation.

### *2.2.1 Market Valuation*

Market value is a price that a consumer would pay for a good or service that is being bought or sold as a commodity. The market valuation is the price value of that product, determined by the market supply and demand. Market price is observable. The market valuation of direct use of forest for example is the price of timber as sold in market or stumpage value. The market value of forests' byproducts for example are prices of fishes or shrimp catchment from forest wetland or swamp. The market value for forest ecological services includes clean water that can be priced and distributed such as bottled natural spring water, or carbon sequestration cost that can be exchanged to carbon taxes or PES programs.

The market value of ecosystem services can also be calculated using replacement cost method which is the cost of replacing ecosystem services and substitute cost method which is the cost of providing substituted ecosystem services (Carson & Bergstrom, 2003). Other market value costs from environmental negative externalities are health costs when environmental degradation is obvious that can be quantified negative health effects (Shin, 2017). Forest ecological services include prevention against natural disaster, which can be translated to prevention cost. One of the examples of prevention cost is flooding damages cost if it were to occur.

### *2.2.2 Non-Market Valuation*

Non-market valuation method is applied when there is no market for such goods such as clean air. The non-market valuation is slightly more complex. The value of such goods is tied to a person's preference which can refer to a monetary value or alternative commodities. The most common form of consumer preference is referred to park fees or donation values. There are two approaches to non-market valuation which are Stated Preference; and Revealed Preference.

Stated preference method uses a hypothetical scenario to create a market condition (Gonzalez, Loomis, & Gonzalez-Caban, 2008). Stated preference rely on the answer to a survey question(s), the answer stated how much individuals value goods or services that do not have a market for. The answers can be in the form of monetary values, choices, rating, or other indications of preference (Brown, 2003). The methods to estimate economic value are Contingent Valuation Method (CVM), Choice Experiment (CE), Attribute-Based Methods (ABM), and Paired comparison. Contingent valuation method (CVM) is perhaps the most widely used and accepted by peer review. CVM is a survey method where individuals are presented with hypothetical information about specific environmental change and ask about their perception, attitudes, and preference (Brouwer, Langford, Bateman, & Turner, 1999). The changes in people's welfare are measured either their willingness to pay (WTP) or willingness to accept (WTA) compensation for the gains or losses (Brouwer et al., 1999).

Revealed preference methods draw statistical inferences on values from actual choice people made within the market. Revealed preference considers observed behavior from consumers to find a demand function. This includes Travel Cost Model (TCM), and Hedonic Pricing Model (HPM). The TCM value is derived from a decision based on whether to take the trip, the amount of money and time spent on that trip associated with changes in environmental quality. Travel Cost Method is used extensively for recreational function. Hedonic Pricing Model is not included in this study data set.

The economic value of the forest is necessary for a policy decision. Policy use of economic value is used for Cost-Benefit Analysis (CBA), environmental costing, and taxes. The value can also be used to calculate compensation payment in Natural Resource Damage Assessment (NRDA), in pollution incidents, or illegal logging.

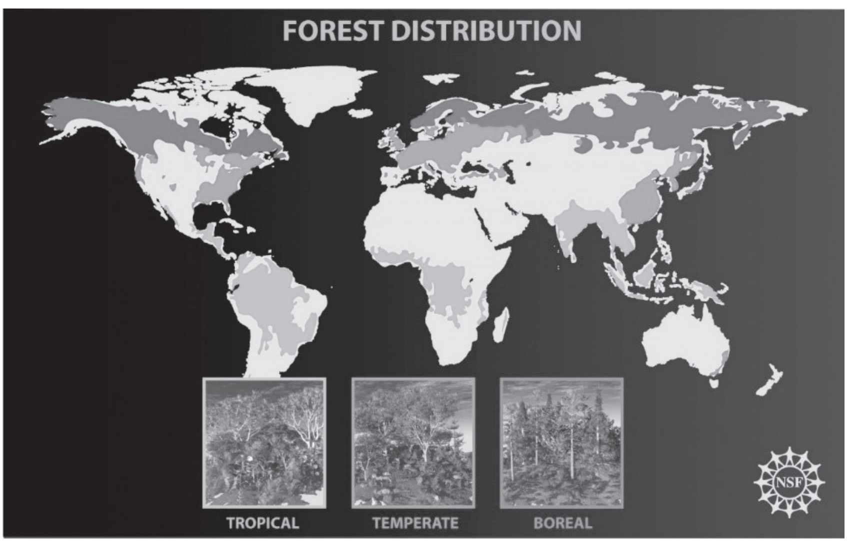
## 3. Forest Classifications

There are many different types of forest and different classification terms. First, we discuss forest classification by latitude, then by tree species and biome.

### 3.1 Forest Classification by Latitude

According to the distance of the area to the equator, the three broad forest zones are Tropical forests; Temperate Forests, and Boreal Forests. These regions define by equatorial lines subsequently give an indication of temperature, and season. The area near the equator has little temperature change throughout the year and is also home of many evergreen forests where there are not much seasonal change, consistent rainfall and the trees are green all year round. In this study, the subtropics region is included in the tropical forest zone. The area between the Polar Circles and Sub-Tropics Circles is classified under the temperate forest zone, which includes North America, and European countries. The area above the Polar Circles, which includes Finland, and Russia is called Boreal Forest where there are cold long winter and short summer.

**Figure 2.** Forest Types by Latitude




**Notes:** Forest Types by Latitude (Boreal Forest, Temperate Forest, and Tropical Forest)

**Source:** National Science Foundation (NSF), 2008

### 3.2 Forest Classification by Tree Species and Biome

There are many names and classification for forest types depending on which source to reference from. However, to narrow down forest can be classified into two major types which are evergreen forest (which are trees that do not shed leaves) and deciduous forest (which are trees that do shed leaves). The factor account for this classification is according to the season. A sub-classification of forest types is further determined by annual rainfall, soil moisture, terrain, climate, and elevation.

Evergreen forests include tropical rainforest or tropical evergreen forest which comprise of hot and wet climate all year round with annual rainfall of more than 200cm per year; cloud forest is evergreen moist forest with large tall trees and situated in high elevation where the moisture comes from the saturated fog in the atmosphere; hill evergreen forest is evergreen forest found in 1000 meters above sea level; dry evergreen forest; pine forest or coniferous forest; swamp forests or wetland; mangroves which are small trees that grow in coastal saline or brackish water; and savanna or grassland which typically found in very hot dry area such as in Africa.

Deciduous forests include mixed deciduous forest or temperate broadleaf which shed leaves during a dry season; and dipterocarp forest which refers to trees in *Dipterocarpaceae* family and can be found in the tropical region on the world, but particularly in Southeast Asia. The broadleaf trees in this biome include oaks, beeches, maples, or birches.

## 4. Data and Methodology

The data set used in this research is from a collection of economic valuation of forest ecosystem all over the world. In Table 1 shows the information data total of 155 observation was gathered from 35 studies from 47 countries. Most of the data used are from published journals with a few researches that are in the working papers stage. Other supporting data used are statistical data from electronic databases such as the world development indicators (Worldbank) and The Economics of Ecosystem and Biodiversity (TEEB). Additional information such as types of forest is found by each country's reports or FRA report and from the internet. Most of the literature are found from looking through the reference list of existing meta-research or studies of a similar topic. One observation was dropped as an outlier for better statistical results. Another eight observations that fall outside the range of 1990 was also dropped. Data extracted from each study were first coded into a Microsoft Excel spreadsheet and then transfer to the Stata program. The regression process was done using the Stata program. The studies research chosen are from the year 1990 to 2014.

**Table 1** List of Forest Valuation Studies

| Author | Year of publication | Observations |
|---|---|---|
| Adams, Alig, McCarl, Callaway, and Winnett | 1999 | 1 |
| Adekunle and Agbaje | 2012 | 1 |
| Asquith, Vargas, and Wunder | 2008 | 1 |
| Bann | 1999 | 2 |
| Beal | 1995 | 1 |
| Bernard, Groot, and Joaquin | 2009 | 2 |
| Borzykowski, Baranzini, and Maradan | 2017 | 7 |
| Boscolo and Buongiorno | 1997 | 1 |
| Boscolo, Buongiorno, and Panayotou | 1997 | 1 |
| Boxall, Englin, and Watson | 1999 | 4 |
| Bush, Hanley, Moro, and Rondeau | 2013 | 2 |
| Chase, Lee, Schulze, and Anderson | 1998 | 6 |
| Chomitz, Brenes, and Constatino | 1999 | 2 |
| Corbera, Kosoy, and Martinez-Tuna | 2006 | 3 |
| Corbera, Kosoy, and Martinez-Tuna (2006); Kosoy, Martinez-Tuna, Muradian, and Martinez-Alier (2007) | 2007 | 2 |
| Day | 1999 | 4 |
| Dixon, Winjum, Andrasko, Leem and Schroeder | 1994 | 14 |
| Dixon, Scura, Carpenter, and Sherman | 1995 | 4 |
| Dutschke | 2000 | 2 |
| Gurluk | 2006 | 1 |
| Johnson and Baltodano | 2004 | 1 |
| Kosoy, Martinez-Tuna, Muradian and Martinez-Alier | 2007 | 2 |
| Lee and Chun | 1999 | 3 |
| Martinez et al. | 2009 | 2 |

**Table 1** List of Forest Valuation Studies (cont.)

| Author | Year of publication | Observations |
|---|---|---|
| Mercer, Kramer, and Sharma | 1995 | 2 |
| Niskanen | 1998 | 2 |
| Otrachshenko | 2014 | 29 |
| Ovaskainen, Mikkola, and Pouta | 2001 | 7 |
| Pattanayak and Kramer | 2001 | 10 |
| Pigiola | 2008 | 14 |
| Postle, Barton, and Thompson | 2005 | 2 |
| Reyes, Segura, and Verweij | 2001 | 4 |
| Rollins | 1997 | 9 |
| Romano, Scarpa, Spalatro, and Vigano | 1998 | 1 |
| Tyrvainen and Vaananen | 1998 | 6 |

The estimated values from existing studies are standardized to US dollars and to the year 2016. Most of the literature gives the values in US dollars, for some data that do not, the local currency is adjusted to US dollars by using an average real exchanged rate of the research conducted year. After which the nominal values of that study year are converted to 2016 values with adjusted inflation rate using the US Consumer Price Index. The inflation was adjusted from the year in which the study was conducted, not the year the paper is published. In the case that the study year was not mentioned in the literature, the published year minus two years was assumed to be the research conducted year.

Many meta-analysis literatures have normalized forest valuation into dollars per hectare per year. However, since the study from all over the world is included, the variance for dollars per hectare is relatively high. The forest value per hectare per person was adjusted to solve this problem and for the resulted value can be easily applied to different size, population, and policy implementation. The valuation was further adjusted to per 1000 persons.

The list of dependent variables and explanatory variables was given below in table 2. The dependent values are normalized to US dollars per hectare per year per relevant population and adjusted inflation rate to the year 2016.

**Table 2** List of Variables

| VARIABLES | CODE | DETAILS | TYPES OF VLBS |
|---|---|---|---|
| *Dependent Variable* | Y | US$ per hectare per 1,000 persons per year (2016) | Dependent |
| *Forest Use Values* | NONUSE | Existence, bequest values, and biodiversity (=1,0 otherwise) | Dummy |
| | USE | Watershed, Recreational, or Carbon sequestration (=1,0 otherwise) | Dummy |
| *Methodology* | CVM | Contingent Valuation Method and Choice Experiment (=1,0 otherwise) | Dummy |
| | TCM | Travel Cost Method (=1,0 otherwise) | Dummy |
| | MKT | Market Value (=1,0 otherwise) | Dummy |
| *Forest Type by Latitude* | TROP | Tropical forest (=1,0 otherwise) | Dummy |
| | TEMP | Temperate forest (=1,0 otherwise) | Dummy |
| | BOREAL | Boreal forest (=1,0 otherwise) | Dummy |
| *Forest Type by Species* | DECIF | Deciduous forest (=1,0 otherwise) | Dummy |
| | EVER | Evergreen forest (=1, 0 otherwise) | Dummy |
| | RAINF | Tropical Rainforest, Moist evergreen, and Cloud forest (=1,0 otherwise) | Dummy |
| | HILLE | Hill evergreen forest (=1,0 otherwise) | Dummy |
| *Forest Type by Species* | PINE | Pine forest or Coniferous forest (=1,0 otherwise) | Dummy |
| | GRASS | Savannah or grassland (=1,0 otherwise) | Dummy |
| | MANG | Mangroves and Wetland (=1,0 otherwise) | Dummy |
| *Forest Area* | AREAP | Forest Area (% land area) | Continuous |
| *Population* | POPD | Population density (people per sq. km of land area) | Continuous |
| *Socioeconomics* | LNGDP | Ln of GDP Per Capita (national level) | Continuous |
| *Regional* | EAS | East Asia & Pacific (=1,0 otherwise) | Dummy |
| | ECS | Europe & Central Asia (=1,0 otherwise) | Dummy |
| | LCN | Latin America & Caribbean (=1,0 otherwise) | Dummy |
| | MEA | Middle East & North Africa (=1,0 otherwise) | Dummy |
| | NAC | North America (=1,0 otherwise) | Dummy |
| | SAS | South Asia (=1,0 otherwise) | Dummy |
| | SSF | Sub-Saharan Africa (=1,0 otherwise) | Dummy |

**Notes:** Forest Type by Species can also be classified into deciduous forest and evergreen forest (includes rainforest, hill evergreen forest, pine forest or coniferous, savannah or grassland, and mangroves)

Dipterocarp forest and dry evergreen forest was illuminate in the study variables due to lack of data available. Table 3 and 4 below shows the range of data between continuous variables and count variables from 155 observations. The continuous variables includes dependent value (Y), forest area in percentage to land area (AREAP), population density per sq.km. of land (POPD), country's GDP per capita (GDP), and natural log of GDP per capita.

**Table 3** Descriptive Analysis of Continuous Variables

| Continuous Variables | Count | Mean | S.D. | Max | Min |
|---|---|---|---|---|---|
| Y | 155 | 65.62 | 371.66 | 3589 | 0 |
| AREAP | 155 | 41.13 | 19.23 | 73 | 0.07 |
| POPD | 155 | 99.47 | 103.82 | 587 | 3 |
| GDP | 155 | 20555.33 | 20610.08 | 80037.50 | 400.03 |
| LNGDP | 155 | 9.32 | 1.28 | 11.29 | 5.99 |

**Table 4** Descriptive Analysis of Count Variables

| Count Variables | Count | Mean | S.D. | Max | Min |
|---|---|---|---|---|---|
| NONUSE | 38 | 0.25 | 0.43 | 1 | 0 |
| USE | 117 | 0.76 | 0.43 | 1 | 0 |
| CVM | 73 | 0.47 | 0.5 | 1 | 0 |
| TCM | 29 | 0.19 | 0.39 | 1 | 0 |
| MKT | 53 | 0.34 | 0.47 | 1 | 0 |
| TROP | 96 | 0.61 | 0.49 | 1 | 0 |
| TEMP | 32 | 0.21 | 0.41 | 1 | 0 |
| BOREAL | 27 | 0.17 | 0.38 | 1 | 0 |
| DECIF | 25 | 0.16 | 0.36 | 1 | 0 |
| RAINF | 77 | 0.50 | 0.50 | 1 | 0 |
| HILLE | 2 | 0.01 | 0.11 | 1 | 0 |
| PINE | 42 | 0.27 | 0.45 | 1 | 0 |
| MANG | 2 | 0.01 | 0.11 | 1 | 0 |
| GRASS | 7 | 0.05 | 0.21 | 1 | 0 |
| EAS | 22 | 0.14 | 0.35 | 1 | 0 |
| ECS | 44 | 0.28 | 0.45 | 1 | 0 |
| LCN | 47 | 0.30 | 0.46 | 1 | 0 |
| MEA | 8 | 0.05 | 0.22 | 1 | 0 |
| NAC | 17 | 0.11 | 0.31 | 1 | 0 |
| SAS | 2 | 0.01 | 0.11 | 1 | 0 |
| SSF | 15 | 0.09 | 0.30 | 1 | 0 |

The regression model adopted in this study is simple Ordinary Least Square (OLS) model.

The formula for model 1 written:

$$Y_i = \alpha + \beta_1 use + \beta_2 Methodology + \beta_3 Forest\ Type\ by\ latitude + \beta_4 Forest\ Area(AREAP) + \beta_5 Population(POPD) + \beta_6 Socioeconomics(LNGDP) + \beta_7 Regional \quad (3)$$

where Y is the dependent variable with i observation, $\alpha$ is a constant number and $\beta$ is the coefficient of the regression.

The formula for model 2 written:

$$Y_i = \alpha + \beta_1 use + \beta_2 Methodology + \beta_3 Forest\ Type\ by\ Species + \beta_4 Forest\ Area(AREAP) + \beta_5 Population(POPD) + \beta_6 Socioeconomics(LNGDP) + \beta_7 Regional \quad (4)$$

where Y is the dependent variable with i observation, $\alpha$ is a constant number and $\beta$ is the coefficient of the regression.

The formula for model 3 written:

$$Y_i = \alpha + \beta_1 use + \beta_2 Methodology + \beta_3 Forest\ Type\ by\ Latitude + \beta_4 Forest\ Type\ by\ Species + \beta_5 Forest\ Area(AREAP) + \beta_6 Population(POPD) + \beta_7 Socioeconomics(LNGDP) + \beta_8 \mathrm{Regional} \quad (5)$$

where Y is the dependent variable with i observation, $\alpha$ is a constant number and $\beta$ is the coefficient of the regression.

## 5. Results

The OLS regression is separated into three models. The first is to test the relationship of forest types by latitude, the second to test forest types by biome, and the third is the combined model of forest type by latitude and a broad category of forest biome (only test deciduous and evergreen). The regression result is summarized in table 5.

**Table 5** Summary of Regression Analysis

| Variables | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| CONSTANT | $^{*}$-884.50 (462.49) | $^{***}$-1117.94 (409.57) | $^{*}$-864.30 (451.55) |
| USE | $^{**}$219.81 (91.39) | $^{**}$269.03 (104.34) | $^{*}$178.90 (90.40) |
| CVM | 111.79 (85.06) | $^{**}$174.38 (84.76) | $^{**}$169.93 (85.57) |
| TCM | $^{***}$-316.61 (100.70) | $^{***}$-365.48 (105.64) | $^{***}$-339.67 (98.65) |
| TROP | $^{**}$-353.52 (138.01) | | $^{***}$-460.36 (139.99) |
| TEMP | $^{***}$-361.39 (133.24) | | $^{**}$-318.66 (130.95) |
| EVER | | | $^{***}$295.46 (105.12) |
| DECIF | | -120.18 (101.97) | |
| HILLE | | 240.51 (234.59) | |
| PINE | | $^{*}$173.68 (89.77) | |
| GRASS | | 289.48 (192.82) | |
| MANG | | 39.04 (265.58) | |
| AREAP | 1.71 (2.10) | $^{**}$4.40 (1.93) | 0.83 (2.07) |
| POPD | -0.47 (0.36) | $^{***}$-0.90 (0.34) | $^{*}$-0.60 (0.35) |
| LNGDP | $^{**}$109.43 (43.13) | 76.14 (46.73) | $^{**}$90.30 (42.65) |
| ECS | 122.09 (123.31) | $^{*}$274.08 (143.25) | 138.60 (120.52) |
| LCN | 8.75 (96.83) | 0.70 (100.82) | 52.14 (95.78) |
| MEA | 261.50 (174.00) | $^{**}$420.42 (176.14) | 184.95 (172.04) |
| NAC | $^{***}$-464.79 (165.93) | -132.67 (167.59) | $^{**}$-370.31 (165.43) |
| SAS | 371.69 (292.19) | $^{**}$696.43 (296.16) | $^{**}$721.15 (311.17) |
| SSF | $^{**}$378.81 (146.71) | 279.85 (179.78) | $^{**}$336.46 (144.01) |
| Observations | 155 | 155 | 155 |
| R-squared | 0.3535 | 0.3694 | 0.3882 |
| Adj. R-Squared | 0.2888 | 0.2912 | 0.3222 |

**Note:** The values are coefficient with standard deviation in brackets
$^{*}p<0.10$, 90% statistically significant
$^{**}p<0.05$, 95% statistically significant
$^{***}p<0.01$, 99% statistically significant

The mean forest value from 155 observations is $US65.62 per hectare per 1000 person per year 2016. The dummy variables Forest use values (NONUSE), Methodology (MKT), Forest Types by latitude (BOREAL), Forest Type by Species (RAINF), and Regional (EAS) was dropped in the regression.

The variable forest use value (USE) is significant with a positive coefficient throughout all three models with variations between 90-95% significant level. In the first model both forest types by latitude are significant with Tropical (TROP) at 95% significant level and Temperate (TEMP) at 99% significant level. Methodology (TCM) is significant at 99% significant level and LNGDP is significant and positive at 95% significant level. In this first model regional variable North America (NAC) and Sub-Saharan Africa (SSF) is significant at 99% and 95% significant level respectively.

The second model was adjusted to test if forest species has statistically significant dependent values. Only Pine forest (PINE) variables of forest type by species is statistically significant at 90% significant level. Methodology CVM is significant at 95% significant level and TCM at 99% significant level. The second model are able to pick up some relationship between dependent variable and forest area at 95% significant level, and population density at 99% significant level but not on GDP per capita. The p-value for LNGDP for second model is at 0.106 which is close to 90% significant level.

In the third model, Forest types by Species was categorize in a broader term where Evergreen forest (EVER) =1, and deciduous forest (DECIF) = 0. Variables (TCM), (TROP), (EVER) are significant at 99% significant level. The variables (CVM), (TEMP), (LNGDP), and three of the regional variables are also significant at 95% significant level. Forest use value (USE) and population density (POPD) are significant at 90% significant level.

This concludes that forest use values, methodology, and forest types by latitudes are significant across all three models. Forest use value represent people perception on forest value including recreation use, forest regulating services, water purification, or carbon storage. The result of forest use value (USE) is highly significant with a positive impact on the dependent variable. Methodology has some influence on forest values. The forest classification when divided by latitude has a significant impact on forest value. Forest type by species also is significant only when classify in a broader term such as evergreen and deciduous. Only one forest type by species is significant when classified into more detail. This could be because once the forest classified into smaller categories, the sample size is reduced thereby the observation is small in some category and may have some selection bias in model 2.

The third model is chosen to predict forest value of an unstudied site. Below is a formula based on meta-analysis model coefficient and Thailand characteristic to predict mean value of forest in Thailand. Thailand is in tropical of cancer so in the forest by latitude tropical input 1 (TROP=1) and assume evergreen forest (EVER=1). According to World Bank's data in 2016, Thailand has 32.1 percentage of forest area, population density is 134.79, and Gross Domestic Product per capita is 5,978.61 USD (natural log of GDP is 8.6959

$$\text{Prediected } \hat{Y} = -864.30 + 178.90(USE) + 169.93(CVM) - 460.36(TROP) + 295.46(EVER) + 0.83(AREAP) - 0.60(POPD) + 90.30(LNGDP) \quad (6)$$

Under above specification and conditions, the result from the simulation for forest use value, conducted by the Contingent Valuation Method (CVM) is calculated to be $US23.94 per hectare per 1000 person per year (in 2016).

## 6. Discussion and conclusions

This study attempts to undertake a meta-analysis on forest valuation. The model in this study takes advantage from a benefit transfer approach by using the secondary data. This study research is based on literature review, therefore the accuracy of the result is primarily based on the analysis of original research. The data used in this research includes 155 observations of forest study all over the world. The study concludes that forest use values, methodology, forest type by latitude, and some forest type by species are statistically significant. Country's socioeconomic factor (LNGDP) is positively significant, meaning as the country become wealthier so do forest values. Meta-regression model 3 was chosen to predict the value of forest in Thailand. The simulation predicts that use value of Thai forest is valued at $US23.94 per hectare per 1000 person per year (value in 2016) or around 845 Baht (using World Bank's official exchange rate in 2016)

This study only allows the estimate valuation of forest in country level in general. Some research studies have included an in-depth study of different areas types such as Borzykowski (2017) have a separate valuation of the forest by zones which Urban, Midland, Jura, and the Alps. By using meta-analysis, a substantial amount of information per individual study is discarded in the standardization process, as well as the decision to keep and drop some variables to improve the degree of freedom. The difficulty in meta-analysis and data collecting is the lack of complete data and some assumptions needed to be made for those incomplete data.

The findings of this research are expected to contribute to policy implication. The accurate cost-benefit study is vital to weight the policy decision. The reliance based on one individual study can create controversy as the assumption people make can be varied as well as methodologies and elicitation technique that can alter the survey results. For example, recreation valuation the total cost one might consider all travel expense including accommodation, eating, shopping, and the opportunity cost of time if not working, some disregard the opportunity cost of time as arguing that leisure vocation is included in the workplace. There are no fixed rules on how the problem is solved but the answer should be within a comparable range.

The value of forest should be in consider as a cycle of ecological services not only timber production or net factor income. Quantify the valuation of forest study into structured systematic procedure can be difficult. However, the benefit of forest can be valued implicitly through policy decisions.

There is a need for more economic valuation studies in Thailand especially in areas of non-market valuation and different types of forest such as dipterocarp forest where the information available are limited. There are continued illegal logging, deforestation, loss of forest in Thailand and all over the world. It is essential for comprehensive study valuation to respond to the current environmental problems. The future direction of policy implication should be aimed more towards a sustainable use of natural environment resources. Preserving a natural environmental resource is seen as investing in the environmental ecosystem and can result in an alternative cost-saving option than to invest in high technology as seen in many cases.

## References

Adams, M., Alig, R. J., McCarl, B. A., Callaway, J. M., & Winnett, S. M. (1999). Minimum Cost strategies for Sequestering Carbon in Forests. *Land economics, 75*(3), 360–374.

Adekunle, M. & Agbaje B. (2012). Public Willingness to Pay for Ecosystem Service Function of a Peri-Urban Forest near Abeokuta, Ogun State, Nigeria. *Journal of Development and Agricultural Economics, 4*(2), 45-50.

Arnqvist, G., & Wooster, D. (1995). Meta-analysis: synthesizing research findings in ecology and evolution. *Trends in Ecology & Evolution*, *10*(6), 236-240. Retrieved from https://doi.org/10.1016/S0169-5347(00)89073-4

Asquith, N. M., Vargas, M. T., & Wunder, S. (2008). Selling two environmental services: in-kind payments for bird habitat and watershed protection in Los Negros, Bolivia. *Ecological Economics*, *65*(4), 675-684.

Bann, C. (1999). A Contingent Valuation of the Mangroves of Benut, Johor State, Malaysia. *Johor State Forestry Department*. Retrieved from http://www.unepscs.org/Economic_Valuation_Training_Materials/06%20Readings%20on%20Economic%20Valuation%20of%20Coastal%20Habitats/14-Contingent-Valuation-Mangroves-Johor-Malaysia.pdf

Beal, D. J. (1995). A travel cost analysis of the value of Carnarvon Gorge National Park for recreational use. *Review of Marketing and Agricultural Economics, 63*(2), 292-303.

Bernard, F., de Groot, R. S., & Campos, J. J. (2009). Valuation of tropical forest services and mechanisms to finance their conservation and sustainable use: A case study of Tapanti National Park, Costa Rica. *Forest Policy and Economics, 11*(3), 174-183. doi: 10.1016/j.forpol.2009.02.005

Borzykowski, N., Baranzini A., & Maradan D. (2017). A travel cost assessment of the demand for recreation in Swiss forests. *Review of Agricultural, Food and Environmental Studies, 98*(3), 149-171. Retrieved from https://doi.org/10.1007/s41130-017-0047-4

Boscolo M. & Buongiorno J. (1997). Managing a tropical rainforest for timber, carbon storage and tree diversity. *The Commonwealth Forestry Review, 76*(4), 246-254. Retrieved from https://repository.si.edu/bitstream/handle/10088/18294/stri_Boscolo_only_1997.pdf?sequence=1&isAllowed=y

Boscolo, M., Buongiorno, J., & Panayotou, T. (1997). Simulating options for carbon sequestration through improved management of a lowland tropical rainforest. *Environment and Development Economics*, *2*(3), 241-263.

Boxall, P. C., Englin, J., & Watson, D. O. (1999). *Valuing wilderness recreation: a demand systems approach in the Canadian Shield* (Vol. 361). Retrieved from http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/11619.pdf

Brander, L. M., Wagtendonk, A. J., Hussain, S. S., McVittie, A., Verburg, P. H., de Groot, R. S., & van der Ploeg, S. (2012). Ecosystem service values for mangroves in Southeast Asia: A meta-analysis and value transfer application. *Ecosystem Services*, *1*(1), 62-69. Retrieved from https://doi.org/10.1016/j.ecoser.2012.06.003

Brouwer, R., Langford, I. H., Bateman, I. J., & Turner, R. K. (1999). A meta-analysis of wetland contingent valuation studies. *Regional Environmental Change*, *1*(1), 47-57. Retrieved from https://esanalysis.colmex.mx/Sorted%20Papers/1999/1999%20GBR%20-Hyd%20Econ.pdf

Brown T. C. (2003). Introduction to Stated Preference Methods. In P. A. Champ, K. J. Boyle and T. C. Brown (Eds.), *A Primer on Nonmarket Valuation* (pp. 99-110). Netherlands: Kluwer Academic Publishers.

Bush G., Hanley N., Moro M., & Rondeau D. (2010, July). *Measuring the Costs of Conservation: A Provision Point Mechanism for Willingness to Accept Estimates of the Impacts of Protected Areas in Uganda*. Paper presented at the Fourth World Congress of Environmental and Resource Economists, Montreal, Canada.

Carson R. M. & Bergstrom J. C. (2003). *A Review of Ecosystem Valuation Techniques: FS03-03.* Athens, GA: The University of Georgia.

Chase, L. C., Lee D. R., Schulze W. D., & Anderson, D. J. (1998). Ecotourism demand and differential pricing of national park access in Costa Rica. *Land economics 74*(4), 466-482.

Chomitz K., Brenes E., & Constatino L. (1999). Financing Environmental Services: The Costa Rican experience and its implications, *The Science of the Total Environment 240*, 157-169.

Corbera E., Kosoy N., & Martinez Tuna M. (2006). *Marketing ecosystem services through protected areas and rural communities in Meso-America: Implications for economic efficiency, equity and political legitimacy*. (Tyndall Centre for Climate Change Research working papers 94)

Cutis S. & Wang Z. (1998). A Meta-Analysis of Elevated CO2 effects on woody plant, mass, form, and physiology. *Oecologia 113*(3), 299-313.

Day, B. (1999). *A recreational demand model of wildlife-viewing visits to the Game Reserves of the Kwazulu-Natal Province of South Africa*. (Center for Social and Economic Research on the Global Environment – CSERGE working Paper GEC-99).

Dixon, J. A., Scura, L. F., Carpenter, R. A., & Sherman, P. B. (1994). *Economic Analysis of Environmental Impacts*. London, UK: Earthscan Publications Ltd. in association with the Asian Development Bank and the World Bank.

Dixon, R. K., Winjum, J. K., Andrasko, K. J., Lee, J. J., & Schroeder, P. E. (1994). Integrated land-use systems: assessment of promising agroforest and alternative land-use practices to enhance carbon conservation and sequestration. *Climatic Change 27*(1), 71–92.

Dutschke, M. (2000). Host country-driven implementation: the case of Costa Rica. In: A. Michaelowa, and M. Dutschke (Eds.), *Climate Policy and Development: Flexible Instruments and Developing Countries* pp. 133–179. Cheltenham, UK, and Northampton, MA, USA: Edward Elgar.

Glass G. V., McGaw B., & Smith M. (1981). *Meta-Analysis in Social Research*. Beverly Hills, CA: Sage Publications.

Gonzalez, J., Loomis, J., & Gonzalez-Caban, A. (2008). A Joint Estimation Method to Combine Dichotomous Choice CVM Models with Count Data TCM Models Corrected for Truncation and Endogenous Stratification. *Journal of Agricultural and Applied Economics 40*, 2 (August 2008), 681-695.

Gurluk, S. 2006. The Estimation of Ecosystem Services Value in the Region of Misi Rural Development Project: Results from a Contingent Valuation Survey. *Forest Policy and Economics, 9*(3), 209-218.

Johnson N., & Baltodano M. (2004). The economics of community watershed management: some evidence from Nicaragua. *Ecological Economics 49*, 57-71.

Joshi P., Jha A., Wani S., Joshi L., & Shiyani R. (2005). *Meta-Analysis to Assess Impact of Watershed Program and People's Participation* (Comprehensive Assessment Research Report 8). Colombo, Sri Lanka: Comprehensive Assessment Secretariat.

Keenan, R. (2015). Forest loss has halved in the past 30 years, latest global update shows. *The Conversation*, *Environment and Energy.* Retrieved from <https://theconversation.com/forest-loss-has-halved-in-the-past-30-years-latest-global-update-shows-46932>

Kooten G., Eagle A., Mandley, & Smolak T. (2004). How costly are carbon offsets?: A meta-analysis of carbon forest sinks. *Environmental Science and Policy 7*, 239-251.

Kosoy N., Martinez-Tuna M., Muradian R., & Martinez-Alier J. (2007). Payments for environmental services in watersheds: Insights from a comparative study of three cases in Central America. *Ecological Economics 61*, 446-455.

Lee, H, C., & Chun, H. S. (1999). Valuing environmental equality change on recreational hunting in Korea: A contingent valuation analysis. *Journal of Environmental Management 57*, 11-20.

Mann, C. C. (1994). Can Meta-Analysis Make Policy? *Science. New Series Vol. 266*, No. 5187, 960-962.

Martiniez M. L., *et al.*, (2009). Effects of land use change on biodiversity and ecosystem services in Tropical Montane Cloud forests of Mexico, *Forest Ecology and Management 258*(9), 1856-1863. doi: 10.1016/j.foreco.2009.02.023

Menkhaus, S. & Lober, D. J. (1995). International ecotourism and the valuation of tropical rainforests in Costa Rica. *Journal of environmental Management 47*, 1-10.

Mercer, E., Kramer, R., & Sharma, N. (1995). Rain forest tourism: estimating the benefits of tourism development in a new national park in Madagascar. *Journal of Forest Economics 1*, 239-269.

Niskanen, A. (1998). Value of external environmental impacts of reforestation in Thailand. *Ecological Economics 26,* 287-297.

NSF (2008), If a Tree Falls in the Forest, and No One Is Around to Hear It, Does Climate Change? News Release 08-102. National Science Foundation. Retrieved from https://www.nsf.gov/news/news_images.jsp?cntn_id=111694&org=NSF

Ojea E. & Martin-Ortega J. (2015). Understanding the economic view of water ecosystem services from tropical forests: A systematic review for South and Central America. *Journal of Forest Economics 21*, 97-106.

Otrachshenko V. (2014). *The passive use value of the Mediterranean Forest*. (Fondazione Eni Enrico Matteri (FEEM) working papers "Note di Lavoro" series 2014.086). Retrieved from http://www.jstor.org/stable/resrep01096

Ovaskainen V., Mikkola J., & Pouta E. (1998). *Estimating recreation demand with on-site data: An application of truncated vs. truncated, endogenously stratified count data models* (Finnish Forest Institute Research Paper 683). Retrieved from https://core.ac.uk/download/pdf/52272514.pdf

Pattanayak S. K. & Kramer R. A. (2001). Pricing ecological services: Willingness to pay for drought mitigation from watershed protection in eastern Indonesia. *Water Resources Research, Vol., 37*(3), 771-778. doi: 10.1029/2000WR900320

Pigiola, S. (2008). Payments for environmental services in Costa Rica. *Ecol. Econ. 65*, 712-724.

Postle, S. L., Barton, H., & Thompson Jr. (2005). Watershed protection: capturing the benefits of nature's water supply services. *Nat. Resource Forum 29*, 98-108.

Randall A., Kidder A., & Chen D. (2008, August). *Meta-analysis for Benefits Transfer – Toward Value Estimates for Some Outputs of Multifunctional Agriculture*. Paper presented at 12th Congress of the European Association of Agricultural Economist (EAAE). Ghent, Belgium.

Reyes, V., Segura, O., & Verweij, P. (2001). Valuation of hydrological services provided by forest in Costa Rica. *European Tropical Forest Research Network (EFTRN) News, 35*(02), 42-44. Retrieved from https://www.researchgate.net/publication/46628387

Rollins, K. (1997). Wilderness canoeing in Ontario: using cumulative results to update dichotomous choice contingent valuation offer amounts. *Canadian journal of Agricultural Economics 45*, 1-16.

Romano, D., Scarpa, R., Spalatro, F., & Vigano, L. (1998, June). *Determinants and Value of Outdoor Recreation in Italian Protected Area: A Travel Cost Random Utility Approach*. Paper Presented at the World Congress of Environmental and Resource Economics, Venice.

Rosenberger R. & Loomis J. (2003). Benefit Transfer. In P. A. Champ, K. J. Boyle and T. C. Brown (Eds.), *A Primer on Nonmarket Valuation* (pp. 445-482). Netherlands: Kluwer Academic Publishers.

Shin, Y. (2017). Economic Evaluation of Environmental Epideminological Projects in National Industrial Complexes. *Environ Health Toxicol, 32*. doi: 10.5620/eht.e2017020

Shrestha R, & Loomis J. (2001). Testing a meta-analysis model for benefit transfer in international outdoor recreation. *Ecological Economics 39*, 67-83.

Smith K. & Huang J. (1995). Can market value air quality? A Meta-Analysis of Hedonic Property Value Models. *Journal of Political Economy Vol. 103*(1), 209-227.

The Economics of Ecosystems & Biodiversity (2017). TEEB Valuation database [Data file] Retrieved from http://www.teebweb.org/

Tyrvainen, L., & Vaananen, H. (1998). The economic value of urban forest amenities: an application of the contingent valuation method. *Landscape and Urban Planning 43*, 105-118.

Worldbank. (2017). Data indicators [Data file] Retrieved from https://data.worldbank.org/indicator

Worldbank. (2017). Forests in Development Cooperation. Agriculture and Rural Development. Retrieved from http://wdi.worldbank.org/table/3.1#

Zandersen M., & Tol R. (2009). A Meta-Analysis of Forest Recreation Values in Europe. *Journal of Forest Economics 15*, 109-13.