ESTIMATING ECONOMIC VALUE OF FOREST ECOSYSTEM SERVICES: A META-ANALYSIS

Tiparpa Ratisurakarn

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Tiparpa Ratisurakarn
School of Development Economics

.... Major Advisor
(Associate Professor Adis Israngkura, Ph.D.)

.... Co-Advisor
(Associate Professor Udomsak Seenprachawong, Ph.D.)

.... Co-Advisor
(Assistant Professor Tongyai Iyavarakul, Ph.D.)

The Examining Committee Approved This Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy (Economics).

.... Committee Chairperson
(Assistant Professor Penporn Janekarnkij, Ph.D.)

.... Committee
(Associate Professor Udomsak Seenprachawong, Ph.D.)

.... Committee
(Assistant Professor Tongyai Iyavarakul, Ph.D.)

.... Committee
(Associate Professor Adis Israngkura, Ph.D.)

.... Dean
(Assistant Professor Amornrat Apinunmahakul, Ph.D.)

______/______/______

ABSTRACT

Title of Dissertation	ESTIMATING ECONOMIC VALUE OF FOREST ECOSYSTEM SERVICES: A META-ANALYSIS
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Forests have significant functions for the global ecosystem. Despite its immense contribution to our wellbeing, deforestation is continuing to be one of the world's biggest problem leading to degradation of environmental and human welfare. In developing countries, there has been ongoing controversy in balancing economic development on the one hand and the need to conserve forests on the other. A key to balancing development and conservation is an accurate estimation of the economic value of forests and use it in decision making. In this regard, innovation in economic valuation of the benefits of forests through environmental valuation techniques will not only enhance the accuracy of the estimation of the forest value but also accurately gear national development towards its sustainable path.

The purpose of the study is to adopt the Meta-analysis to estimate the economic value of forests. Meta-analysis is a statistical tool for synthesizing and integrating outcomes of previous studies into a more general form. The Meta-analysis developed in this study is based on the ordinary least square estimation of Meta-equations that contain various features of forest valuation, they are, types of forest ecosystem services, methodologies, forest types by latitude, forest types by biome, percentage of forest area, population density, and country's GDP per capita. In this study, 301 forest values were gathered from 81 past research articles and studies. After eliminated some outliers, 288 observations of forest values were used to perform the Meta-analysis.

The Meta-regression result shows that methodologies, forest types, the scale of research, protected level of the forests, and population density have a significant impact

on forest values. The result of the Meta-analysis shows the mean economic value of forests to be $US8.95 per hectare per 1000 person per year (in 2017).

The Meta-regression result of the third model is selected to predict the value of forests in Thailand. After adjusting the equation to the Thai socioeconomic status, population density, and forest areas in 2017, the predicted value for Thai forests at a country level is between 935 and 9,453 international dollars per hectare in 2017. This is comparable with the actual range of Thai forest values from original studies which range between 194.56 and 28,412.72 international dollars per hectare in 2017.

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

ABBREVIATIONS

Abbreviations	Equivalence
ABM	Attribute-based methods
BT	Benefit Transfer
CBA	Cost-Benefit Analysis
CC	Contingent Choice
CE	Choice Experiment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CM	Choice Modeling
CS	Consumer Surplus
CV	Contingent Valuation
CVM	Contingent Valuation Method
EEPSEA	Environment Program for Southeast Asia
ESVD	The Ecosystem Services Valuation Database
ETFRN	European Tropical Forest Research Network
EVRI	Environmental Valuation Reference Inventory
FAO	Food and Agriculture Organization
FEEM	Fondazione Eni Enrico Matteri
FRA	Global Forest Resources Assessments
GDP	Gross Domestic Product
GVM	Group Valuation Method
HPM	Hedonic Pricing Model
IIED	International Institute for Environment and Development
IUCN	International Union for Conservation of Nature
LCU	Local Currency Unit
NASA	National Aeronautics and Space Administration
NRDA	Natural Resource damage assessment

Abbreviations	Equivalence
OER	Official Exchange Rates
OLS	Ordinary Least Square
PES	Payment of Ecosystem Services
PPP	Purchasing Power Parity
RP	Revealed Preference
RUM	Random Utility Model
SJR	Scimgo Journal & Country Rank
SP	Stated Preference
TCM	Travel Cost Model
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
VIF	Variance Inflation Factor
WRI	World Resources Institute
WTA	Willingness to Accept
WTP	Willingness to Pay

CHAPTER 1

INTRODUCTION

1.1 Research Problem

The growth in human population leads to resources scarcity including food and land. The declining rate of environmental quality has put more pressure on the policymakers to make a decision on natural resource management (Richardson, Loomis, Kroeger, & Casey, 2015) This leads to a growing demand for better management of eco-service system flows, and economic values of those services for better judgment and public policy decisions.

Forest is one of the main influences in ecosystem services. Other than its provision services forest also helps regulate the hydrological system, provides clean air, absorb carbon, and serves as a source of biodiversity. High deforestation rate causes a disruption of the ecological system as evident in the current situation such as climate change, loss of biodiversity, flooding, soil erosion, and landslides (Menkhaus & Lober, 1996). Over the years people have gradually become more aware of the global warming phenomenon and the relationship between forests and greenhouse gas emission. Many government and private organizations have established programs for reforestation and afforestation to help sequestrate carbon and improve biodiversity. However, the restoration effort has been made quite recently and more so from the developed countries.

The turning point for global environmental concerns and the need for environmental-economic valuation was from environmental damage caused by the large oil spill. The Exxon Valdez oil spill in 1989 causes major environmental concerns and society became aware of the environmental impact on a global scale. The impact was immense that after three years of cleaning polluted beach still found that the shoreline was still contaminated with subsurface oil. The source of this controversy has been the use of hypothetical contingent valuation surveys to assess damages from individual households, and the aggregation of these survey values overall households in the United States. The non-use economic values were considered in damage assessment (Richardson et al., 2015). In a report to the Attorney General of the State of Alaska, contingent valuation study was employed to assess the damage (R. T. Carson, Mitchell, Hanemann, Kopp, & Ruud, 1992). The Exxon Valdez study has significantly impacted the way in which CVM studies are viewed, evaluated, and proposed. The study estimated a median willingness to pay (WTP) for a spill prevention plan to be approximately $31 per household, which result in an aggregate damage assessment of $2.8 billion (Harrison, 2006). This shows that the economic valuation of ecosystem goods and services are needed for the government to make informed resource policy decisions. The environmental valuation can be used for cost-benefit analysis, allocate budget, calculate taxes and fees, as well as penalties to prevent future damages, and compensation to those affected.

Forest valuations are needed to find economic values of the forest as reflected from society. Forest area and quality of the forest are constantly declining, therefore the need for sustainable management of forest use is necessary. However, to manage forest requires an accurate and meaningful valuation in order to be able to weigh the costs and benefits of their conservation (Brouwer, Langford, Bateman, Crowards, & Turner, 1999). The ecosystem value of forest includes forest values that have been accounted for loss prevention such as flooding and landslides, loss of biodiversity from deteriorated forest quality or reduced forest area. The non-market valuation of forest needs to translate in monetizing values so that policymakers can make a decision, budget allocation, and compare with other options. There are many studies on the economic value of forest in stumpage value, some are on ecosystem service value of forests with a focus on one or two types of service. There still a need for more research to understand embedding effects for intricate environmental goods.

As there is more awareness in environmental studies, the list of environmental valuation research is ever-expanding. The non-market valuation branch of environmental economics has developed a rich but still immature meta-analysis literature since Smith and Kaoru's in 1990 (Lindhjem, 2007). It is essential to find an acceptable economic valuation, especially in developing countries.

Forests are often undervalued, perhaps this is due to the reason that most people do not understand the full underlying values of the forest. In the stated preference (SP) method, respondents often find difficulties in assessing a complex and multidimensional forest good (Lindhjem, 2007). Many economic studies also presented their findings with conservative estimation. Therefore, policymakers often make a decision according to its undervalued price. Apart from its direct value of timber product, the non-timber product can be used to produce medicine and other forest byproducts. Forests create many positive externalities such as conservation of biodiversity, tourism, recreational destination, provide shades and shelter, reduce carbon dioxide in the atmosphere and temperature, erosion control, prevent flooding, and protection from a natural disaster (Türker, Öztürk, & Pak, 2003). On the other hand, overvalued forests will deprive the economy of engaging in meaningful development that aims to increase income but will infringe on forest coverage. Presently, there are many non-market ecological types of research in developed countries but fewer in developing countries particularly in South East Asia where deforestation rate is alarming. Lack of knowledge in forest valuation may lead to uninformed decision making and worsen deforestation trend.

Over the past years, there is an increasing number of studies on forest and forest valuation. The monetary value in forest valuations is used for the cost-benefit analysis for many projects for both private and public organizations. To conduct individual environmental valuation studies requires time and money for surveys and analysis. For projects that have limited time and budget constraints, researchers use secondary data and use benefit transfer (BT) methodologies. The problem with using benefit transfer is the transfer error, average transfer error for spatial value transfers both within and across countries tends to be in the range of 25%-40% and individual valuation transfer could have errors as high as 100% (Ready & Navrud, 2006). Benefit transfer has an advantage in reduced time and cost of conducting research, but also a disadvantage in transfer error. Many techniques have been proposed to reduce those errors, but it mainly depends on compatibility from the study site and policy site, the relevance, methodologies, environmental quality, socioeconomic characteristics, and the level of accuracy and details from primary data.

A systematic review is adopted to understand the meaning of existing studies where the information is abundant. Researchers use meta-analysis as a statistical tool to understand the underlying behavior that is reflected in numerous studies of the same issue. By using individual studies each with different purpose and methodologies, and systematically combining that information. Meta-analysis is used to synthesis these research findings. It was first used in clinical trial started in a simple form of comparing weighted means according to sample size. Since then Meta-analysis has been used in multiple fields and in environmental economics. The meta-analysis research studies conducted include travel cost recreation demand models of consumer surplus (Smith and Kaoru, 1990); hedonic valuation of air pollution (Smith & Huang, 1995); elevated carbon effects (Curtis & Wang, 1998); carbon forest sink (Van Kooten, Eagle, Manley, & Smolak, 2004); on assess the impact of watershed program (Joshi, Jha, Wani, Joshi, & Shiyani, 2005); and benefit transfer estimated value for multi-function agriculture (Randall, Kidder, & Chen, 2008).

Some of the meta-analysis published work on forest valuation includes forest recreational values (Shrestha & Loomis, 2001; Zandersen & Tol, 2009); the valuation of ecosystem services for mangroves (Brander et al., 2012); passive use-value of Mediterranean Forest (Otrachshenko, 2014). The unit of measurement for forest valuation slightly varies, many studies use a per hectare basis while others use per visit or per household. For Shrestha and Loomis (2001) valuation of forest recreational values standardize the results to consumer surplus per person day. Zanderson and Tol (2009) study use a log of consumer surplus and consumer surplus per hectare as a dependent variable. Otrachshenko (2014) similarly presented the WTPs in marginal values for the Mediterranean forest.

Currently, there are many existing studies on forest valuation studies on individual site of the forest with each study has different purposes and different interpretation in terms of methodology and its uses. Most of these research studies conducted are from developed countries. There is still room for improvement and further research in developing countries where there are going debate on balancing the country's growth with environmental quality. In Thailand, the ongoing debate in deforestation causes the government to look for acceptable forest valuation standards to be used in cost-benefit analysis and assist in government in making a policy decision. The ongoing issues in Thailand include a decision on whether to preserve the forest versus building an electrical dam, and penalty measures for illegal forest cut down in national park and reserves area. These ongoing issues are also similar to other developing countries in neighboring countries

Policymakers may face a problem of picking which research is best to base their decision on to make a sound policy or to issue 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 as seen in many published counter-argument. For examples, Beal's (1995) travel cost estimates of the value of Carnarvon Gorge National Park was criticized by (Kennedy, 1998) for overestimating and (Chotikapanich & Griffths, 1998) for underestimating. Later, Beal (1998) published an article to explain her argument. Similarly, Núñez and Nahuelhual (2008) published their commentary after some criticism on the paper "forests and water: The value of native temperate forests in supplying water from human consumption" to explained their work in 2006 (Núñez, Nahuelhual, & Oyarzun, 2006).

Some of these errors occurred because of technical errors while others might be intended by political reasons. For this reason, conducting a Meta-analysis on forest service is essential for a developing country such as Thailand.

The research questions for this study are:

1. Are the economic values suggested by published forest valuation studies consistent and the variation of these forest values across studies can be explained by Meta-Analysis?

2. Can the Meta-Analysis of forest values be applied to forest valuation in Thailand?

1.2 Research Objectives

Ecosystem and biodiversity are vital to our very existence. As many policymakers are often not familiar with its values, better consideration of nature can help to achieve other policy goals as well. The Economic and Ecosystems and Biodiversity - TEEB (2013) express that by understanding the ecosystem and biodiversity will help policymakers understand the social impacts and dependencies; enhance and develop sectorial policies and conservation policy such as energy, water resource management, and flood prevention; can help save public funds; and raise public awareness of the roles and importance of nature for society.

Economists' measure forest valuation in terms of forest service as it reflected on individuals' welfare. Forest has multiple uses, services, and functions. Forest use can be overlap and combining its value can be complex. The scales of each forest valuation studies vary between the world, regional, countries, province, a land, or a plot. Therefore, the value estimated for each scale and scope can be vastly different. There are a few methodologies as well as different classifications for forest types. This study will aim to identify how these classifications affect forest value estimates.

The main objectives of this study are:

1. To undertake Meta-Analysis on forest values and examine how variations of these forest values can be explained by factors such as forest characteristics, methodologies adopted in those studies and different socio-economic conditions where the studies were carried out.

2. To verify the result of the Meta-Analysis above with validity test and apply it with the simulated forest characteristics and socio-economic situation in Thailand.

1.3 Scope of the study

The scope of this study is to obtain meta-analytical estimates of forest valuation for ecosystem services provided by the forest. Ecosystem services as according to The Economics of Ecosystems and Biodiversity (TEEB) can be classified into four types which are provision services; habitat services; regulating services; and cultural services. This research study is primarily based on literature review, therefore meta-analysis is adopted as a statistical tool to understand the results of existing researches. The data used in the meta-analysis are based on forest valuation from existing studies all over the world. These forest values are used to estimate the meta-equation that shows a statistical relationship between forest values and a set of explanatory variables.

This study will cover an introduction to forest ecological services, forest classifications, and methodologies use in environmental valuation. The meta-analysis is applied to use, and non-use values estimate provided by the forest ecosystem. The Meta-regression is applied to help understand which factors that influence forest valuation. As the subject of interest concerns with individual’s welfare as well as how population density affects forest values, the results of this research are interpreted in mean valuations in terms of per hectare used per a thousand person.

1.4 Contribution of the study

There are currently many existing studies on the meta-analysis on environmental such as air quality, recreational forest, and carbon sink cost. The existing meta-analysis on forest values only focus on either specific type of function or focus on one continent, or both such as Zanderson and Tol (2009) focuses on forest recreation values in Europe; Shrestha and Loomis (2001) 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. The existing studies on meta-analysis focus on one country include meta-analysis estimates of environmental services value in the United States that enhanced by government agricultural conservation programs (Borisova-Kidder, 2006).

The existing study of meta-analysis on forest valuation with non-use focuses is by Lindhjem (2007) on non-timber benefits from the forest in Sweden, Norway, and Finland. The three Scandinavian countries are similar in geographic, culture value and economic condition, therefore the difference between each country is not significant. However, for benefit transfer to use the value estimate only from developed countries to developing countries the results can be misleading and inaccurate.

The original idea for this study is to conduct forest valuation for South-East Asia. As the countries in this region are originally abundant of tropical forests and home of many exotic plant species and protected animals. Similar to many other developing countries South-East Asia countries face similar problems of the corrupted political system and the need to balance between economic growth and environmental conservation. However, the data of reliable forest study in South East Asia are limited to conduct a reliable estimate. The benefit transfer from ‘study site’ to ‘policy site’ criteria is that the site needs to be similar in characteristic to reduced transfer error. In the Nordic region, for example, researchers can use information from the forest study site in Sweden to a policy site in Norway with some adjustments to make an acceptable transfer error percentage. Thailand can use benefit transfer from Northern forest site valuation and compares with Burma or Laos. The disadvantage of this is that Thailand

and comparable neighboring countries are also developing countries, where existing research conducted are few and non-market forest valuation is limited. The available information might not be applicable to the 'policy site' such as inappropriate methods, or a different area of focus. Therefore, the idea is by using enough available information from both developed countries and developing countries with adjustment to geographic and economic conditions in explanatory variables, the researchers and policymakers can use the information on policy forest site. The forest value estimates would be standardized, and the information can be accepted from reliable source and institutions.

The contribution of this study will provide overall estimates for all forest types and regions. Once the value per hectare per person is established it can be used to assist policymakers by providing a more comprehensive set of information that can be readily used. Emphasis is also placed on developing countries where regulations may be weakened to satisfy economic growth, and technological advances may be limited. By combining the forest valuation estimates between use and nonuse function would help to explain the total economic value of complex ecosystem service such as forest values. Using the benefit transfer (BT) method, Meta-analysis regression results can provide estimate forest value simulation from forest's studies site to policy forest site, to assist policymakers to implement a sound policy.

CHAPTER 2

LITERATURE REVIEW

Forest serves multiple services and benefits. Forest ecosystem and structure are highly interrelated which makes it very hard to distinguish completely. To understand the forest ecosystem values first, we look at the environmental economic valuation and valuation methods.

2.1 Environmental Economic Value

Environmental goods and services can be broadly categorized into use and non-use values. The use-value can be further categorized into direct use that comes from consumption and non-consumption use of forests such as timber, fuel and forest byproducts; and indirect use derives from forest services such as watershed protection, hydrological functions, biodiversity protection, soil protection, carbon storage and carbon sequestration. Nonuse value includes existence value, passive use-value, and bequest value.

Bergstrom, Stoll, Titre, & Wright (1990) classified forest value into current use value and future use values (figure 2.1). The non-use value, current and future use value are calculated in consumer surplus, then translate into individual new willingness-to-pay and total aggregate net benefits. Consumer surplus is a measure of the net benefit received by the consumer of a good and is measured by the difference between the amount the consumer is willing to pay and the actual price (Beal, 1995).

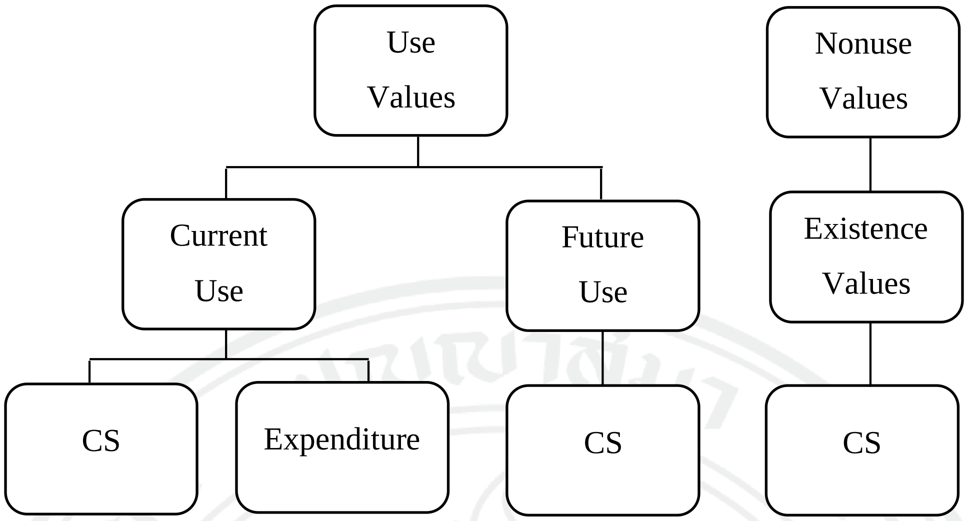

Figure 2.1 Economic Values Use and Nonuse

2.2 Economic Valuation Method

The environmental economic valuation method can be broadly 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 the product determined by the market supply and demand. The market price is observable and measurable. This includes **direct market pricing** or **factor income** which is the estimates values for ecosystem products and services that are bought and sold in commercial markets. The market valuation of direct use of the forest is the price of timber as sold in the market or the stumpage value. The market value of forests' byproducts such as prices of fishes or shrimp catchment from forest wetland or swamp, or a result of bioprospecting in commercialized medicinal use.

The market value for forest ecological services that are more intangible includes clean water which can be priced and distributed such as bottled natural spring water, or carbon sequestration cost that can be exchanged to carbon taxes or Payment for Ecosystem Services (PES) programs.

Payments for Ecosystem Services (PES) are incentive based scheme for landowners to manage their land or keep their forests or trees for others to receive ecological benefits. The scheme is introduced to eliminate the ‘free riders’ problem. As the benefits provided by ecosystem services are not priced, resource users do not take into account the degradation of these services (Corbera, Kosoy, & Martínez Tuna, 2006). The incentives are introduced to entice landowner to take better care of their ecosystem services and for users to pay for its benefits. For example, in the case of Los Negros valley in Bolivia, farmers are paid to protect 2774 hectares of a watershed through PES scheme. The contracts prohibit tree cutting, hunting and forest clearing on enrolled lands (Asquith, Vargas, & Wunder, 2008). For a landowner to accept PES, the incentive values need to be higher than the alternatives.

The market value can also be estimated 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). Forest ecological services include prevention against natural disaster, which can be estimated as **prevention cost** or avoided cost. The **avoided cost** method estimated the economic values based on the costs of avoided damages resulting from lost ecosystem services (Van der Ploeg, De Groot, & Wang, 2010). The **mitigation and restoration cost** is the estimated ecological values based on costs of mitigating or restoring damaged ecosystems of goods and services (Van der Ploeg et al., 2010). Other market costs from environmental negative externalities are health costs associated with environmental degradation which can be quantified as negative health effects (Shin, 2017).

Compares the actual economic loss and damages with prevention cost, based on many cases the prevention cost is much less. In 2011 Thailand experienced one of the worst economic loss from flooding in the past 50 years. The economic loss and damages caused by 2011 floods were estimated to be 1.4 trillion baht (47billion USD) (Nabangchang, Leangcharoen, Jarungrattanapong, Allaire, & Whittington, 2015). The amount equivalent to about half of an average household's annual expenditure. The data was gathered from a survey sample and interviews based on actual repair and replacement cost. The mean total floods cost per household was 162,050 baht, which 66% of the total cost occurred after the floods. The foregone income was one of the largest components of non-health related loss, the mean cost was 27,726 baht (885 USD) per household.

The economic value of ecosystem services can be captured in a Total Economic Value (TEV). TEV is the value obtained from the various constituents of utilitarian value, including direct use value, indirect use value, option value, quasi-option value, and existence value (TEEB - The Economics of Ecosystems and Biodiversity, 2013) However, the term 'total' should be interpreted with caution as it is a general concept not an interpretation of 'all' the different economic value components of the TEV concept assessed. Total Economic value consists of use and non-use value, and not to be confused with total ecosystem value (Pearce & Turner, 1990)

2.2.2 Non-Market Valuation

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

Stated preference

Stated preference method uses a hypothetical scenario to create a market condition (Gonzalez, Loomis, & Gonzalex-Caban, 2008). Stated preference reply on the answer to a survey question, the answer stated how much individuals value goods or services that do not have a market for. These answers can be in the form of monetary values, choices, rating, or other indications of preference (T. C. Brown, 2003). The stated preference method includes the contingent valuation method (CVM), and attribute-based methods (ABM).

Contingent valuation (CV) is a survey-based methodology for eliciting values people placed on goods, services, and amenities (T. C. Brown, 2003). Contingent valuation method was first conducted by Davis in 1963 to estimate the value of big game hunting in Maine. 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 et al., 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.

Some of the earlier criticism CVM faces is considered as a "short cut" and for using a hypothetical question would get a hypothetical answer. However, such criticism was deflected by Bishop and Heberlein's study in 1979. The study compared the validity test of contingent valuation with travel cost model and cash transaction and found a similar magnitude of WTP estimates. Contingent valuation became prominent in environmental economics scene when the method was admitted in legal cases as the basis of damage payments by parties responsible for large-scale pollution under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 (Boyle, 2003). The notable case was the settlement of the Natural Resources Damage claim from the Exxon Valdez oil spill in 1989. The contingent valuation method is perhaps now the most widely used and accepted by peer review for non-market valuation.

The improvement and research study on CVM has been mainly focusing on design implementation. There is still ongoing criticism on the contingent valuation method, more so on survey design. Cameron (1992) argues that there is a high potential bias in poorly designed CVM surveys. Cameron further argues that when looking at a hypothetical context is inconsistent with the observed behavior in the real market. The potential bias about using CVM is that an individual might not reveal the true valuation. The valuation bias is depending on respondents' perception of who will pay for the service. If someone else pays he or she will have the incentive to overstate his/her willingness to pay (Whittington, Briscoe, Mu, & Barron, 1990). If the decision has been made to improves the services for that, he or she will understate in order to pay less for the assess charges. Fear of paying for ecosystem services in the future or fear of if stated WTP less the project might not go ahead.

The survey design and elicitation technique impacted the decision process made about how much the respondents value an ecosystem. Whether it is an open-ended question or closed ended question the answer from the same respondent may be different based on how the question is framed. The interviewers need to keep in mind about different elicitation techniques and designing a survey such as if the payment card system is introduced what should be the choice of answer or which range of monetary values. If respondents can answer ‘0’ as WTP and should ‘0’ be included in the data or not. Therefore, many of the CVMs have been improved within the study from pre-survey design, questionnaire wording, the use of payment card, and WTP ranges. The survey that over-exaggerated the WTP, or falls outside the norm was usually eliminated for better-quality results.

It is important note that while some contingent valuation method is asked in the form of willingness to pay (WTP), which is also subjected to individuals or household income constraints. Pattanayak and Kramer (2001) also pointed out that in some cases WTP reflects the ability to pay rather than the willingness to pay.

Similar to the contingent valuation method, **group valuation methods (GVM)** estimate the economic value of direct willingness to pay based on a hypothetical scenario but instead of individual preference, the question is asked towards a group of people.

Other survey-based methods using a different eliciting technique are attribute-based methods (ABM). The object of **attribute-based methods (ABM)** is to estimate economic values for a technically divisible set of attributes of an environmental good (Holmes & Adamowicz, 2003). This provides resourceful information about public preference. The most popular format for conducting ABMs are rating, ranking, and choice. ABMs formats are based on a random utility model (RUM) of choice behavior. Random Utility Maximizing model (RUM) is a method where respondents choose the most preferred alternative from different options in terms of attributes and levels (Brey, Riera, & Mogas, 2007). Choice-based ABMs are perhaps the most popular. A survey choice-based stated preference is also called contingent choice (CC), choice experiment (CE), and choice modeling (CM). Other choice-based valuation and ABMs will all refer to as Contingent Choice. **Contingent Choice** (CC) as defined by TEEB (Van der Ploeg et al., 2010) estimates economic values based on asking people to make tradeoffs among sets of the ecosystem or environmental services or characteristic but does not directly ask for willingness to pay. Contingent Choice is widely used in the late 1990s. The studies that use the contingent choice methodology in forest valuation related research includes public WTP for ecosystem service in Nigeria (Adekunle & Agbaja, 2012) and forest values in Spanish forests (Brey et al., 2007).

Revealed Preference

Revealed preference methods draw statistical inferences on values from actual choice people make 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. Hedonic pricing models generally refers to property value models. It is based on people decision about the location and environment and transfers that decision to market value. HPM data is not included in this study.

The travel cost method is used extensively for recreational function. The travel cost method was first used by Clawson and Knetsch in 1966. The travel cost method can be further separated by TCM by zonal where the calculation is based on the distance of a respondent to the site, and individual TCM is based on an individual cost traveling to the site. The individual travel cost method can be further separated into a single site and multiple sites.

The economic value of a forest is necessary for a policy decision through 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.

2.3 Benefit Transfer

Benefit transfer (BT) is the use of existing data or information from one setting and used in another setting. The practicality of using available information by transferring information such as valuation or function from 'study site' or multiple study sites to an unstudied 'policy site' that is being evaluated (Richardson et al., 2015). The term benefit transfer is a colloquial term adopted by economics and means the use of existing data or information in settings other than for what it was originally collected (Shrestha & Loomis, 2003).

Benefit transfer approaches can be broadly classified into 1) unit value transfer and 2) function transfer. Figures 2.2 shows the types of BT in value transfer and function transfer.

Unit value transfer entails the direct application of summary statistics from original research to a policy context. There are three approaches to value transfer. The first is to identify a single study that best matches the characteristic of a policy site, adjust the inflation then transfers this single point estimate. The second approach uses an average value from several studies to the policy site which is called transfer of central tendency. The reasons for using the second approach could be either that there are multiple studies that meet the criteria and including multiple studies would be more accurate, or that there are no studies that meet all the criteria and using average value may reduce bias. The third approach is the use of administratively approved values such as U.S. Forest Service Resource Planning Act values, or U.S. Water Resources Council's unit day values for recreation. (Richardson et al., 2015).

Function transfer entails the application of a statistical function that relates the summary statistics of original research to the specifics of the study site. A function transfer could be a transfer of demand function, a function of the benefits or willingness to pay from the study site to the policy site. Benefit function transfer then tailors the function to fit the specifics of the policy site by setting the values of independent variables such as socioeconomic characteristics or other measurable characteristics that differ from the study site (Loomis, 2005). Meta-regression analysis is another approach in function transfer that relies on statistical relationship defined for certain variables based on several studies (Rosenberger & Loomis, 2003).

Benefit function transfer can include information from one or a few similar studies. Function transfer that includes information from many studies is called 'meta-analysis'. Meta-regression analysis function transfer address some of the drawbacks of benefit transfer. Meta-regression systematically accounts for differences in results and explanatory variables in relevant methodological studies to estimate the WTP function of ecosystem service (Richardson et al., 2015).

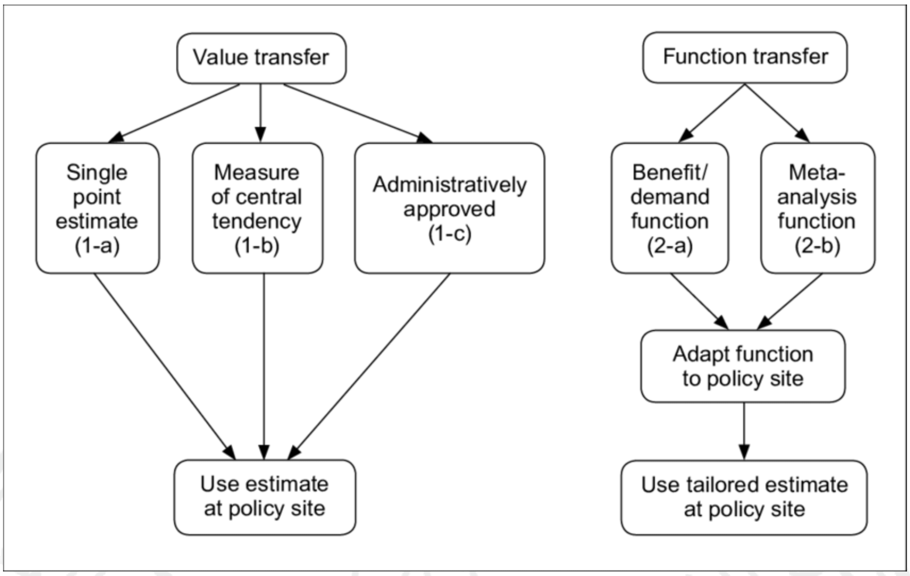

Figure 2.2 Types of Benefit Transfer
Source: (Loomis, 2005)

The process of benefit transfer valuation started with Freeman's article in 1984 on 'the tactics of benefit estimates'. The criteria of a value estimate for valid transfer are based on adequate data, sound economic method, and correct empirical technique (Richardson et al., 2015). By 1992, systematic research was being conducted to develop procedures and test the validity of benefit transfer. This includes developing criteria for benefit transfer. The three criteria for value transfer as proposed by Boyle and Bergstrom (1992) are:

1. The nonmarket commodity valued at the study site and policy site are identical
2. The populations affected by the nonmarket commodity at the study and policy sites have identical characteristics; and
3. The assignment of property rights at both sites must lead to the same theoretically appropriate welfare measures.

From 2000, more studies have continued to expand on ways and protocols to use original research for valid benefit transfers. The literature outlines the steps and protocol for good practice for conducting primary research with a focus on stated preference as well as protocols for the transfer of results in nonmarket valuation. Brouwer (2000) identify 7 steps towards a protocol for good practice which are:

Step 1 Defining the environmental goods and services

Step 2 Identifying stakeholders

Step 3 Identifying values held by different stakeholder groups

Step 4 Stakeholder involvement in determining the validity of the monetary environmental valuation

Step 5 Study selection

Step 6 Accounting for methodological value elicitation effects

Step 7 Stakeholder involvement in value aggregation

By defining the environmental goods and services clearly will keep the analysis transparent and avoid double counting (Brouwer, 2000). Double counting can be problematic defining such complex values in ecosystem services as the valuation of one ecosystem service is sometimes captured, reflected or incorporated in another. For example, the value of clean water might be measured by the avoided health care costs or by a survey of consumer WTP for clean water. However, if the consumer desire for clean water is due to (in part) to their desire not to fall sick then the value of clean water will be over estimate (TEEB - The Economics of Ecosystems and Biodiversity, 2013). When assessing the WTP, the questions should be stated clearly as much as possible to avoid this double-counting and make sure that values are not replicated or repeated in different estimates.

To minimize the transfer error, the closer the study site is to the policy site, the closer the goods and services being valued by the population affected (Ready & Navrud, 2006). While it is advisable to find the study site as close to the policy site in terms of location, types, classification, and proximity, sometimes it is necessary to use study site from other countries, Ready and Navrud (2006) has pointed out challenges when face with international benefit transfer context, or even in intra-country issues which includes currency conversion, difference in characteristics and culture.

For non-timber benefit, the simple unit transfer includes both use and non-use value. For use-value, a unit of valuation is consumer surplus/ activity day. For non-use value unit value transfer measurement is WTP/household/year. To convert the values into international unit value transfer need to consider for PPP-adjusted exchange rates as well as inflation rates.

The study site use for benefit transfer should be within comparable range and fit the study criterion. The transfer value of welfare especially in ecosystem service is particularly difficult as the value that one's place depends on perception, utility, and how the question was framed is different. The utility measured is according to the person's perception and the law of diminishing utility (Richardson et al., 2015)

Transfer error (TE) is the percentage difference between the transferred (WTP_T) and policy site primary estimate (WTP_p) (Lindhjem & Navrud, 2008)

$$TE = \left|\frac{WTP_T - WTP_P}{WTP_P}\right|$$

The average transfer error for spatial value transfer both within and across countries tends to be in the range of 25%-40%, while individual transfer could have errors as high as 100% (Ready & Navrud, 2006). A Meta-Analysis is a useful tool for benefit transfer application. However, Bergstrom and Taylor (2006) pointed out that there is a need for convergent validity tests. A meta-analysis that has investigated the validity and reliability includes Rosenberger and Loomis (2000); Shrestha and Loomis (2001, 2003). Though the results show high transfer errors of value estimates but nevertheless still reliable enough for cost-benefit analysis.

2.4 Meta-Analysis

Meta-analysis is another application of benefit function transfer. 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. Meta-analysis is the findings of empirical studies. It helps to extract information from large masses of data in order to quantify a more comprehensive assessment (Brouwer et al., 1999). A meta-analysis helps explain the differences in outcomes from single studies on the basis of differences in underlying assumption. The re-analysis of primary data could answer the new question with old data or with improved statistical techniques (Glass, McGaw, & Smith, 1981).

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 multiple disciplines since, but mostly for clinical data. Early work of Meta-analysis used to combine weighted results from study treatments. It looks at a statistical measure "effect size" - the difference between the result observed by an experimental treatment and the expected result if the treatment had no effect.

One of the main reasons for meta-analysis popularity is that it also reduces the 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 researchers may miss the link of finding an association or effect. In statistic rule, about 68% of values fall within one standard deviation of the mean, 95% falls within two standard deviations of the means, and 99.7% falls within three standard deviations of the means. In general, studies often set the normal distribution at a 95% confidence interval to accept the hypothesis, or 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 significant of those with lower percentile and reject the hypothesis. A meta-analysis, on the other hand, takes into account the distribution of all effect sizes, significant or not, so it may pick up on the signal that the individual studies may not be able to pick up.

When integrating research findings, the typical report on the findings would first run the correlations between two variables from study to study (Hunter & Schmidt, 2015). Then the breakdown of the findings for each variable if significant or not significant. A meta-analysis suggested that the number represented may include sampling error. By computing variance of the correlations, weighting each by its sample size would get the standard deviation.

Some of the earlier work of meta-analysis in clinical field is the simple form of comparing weighted means and assign more confidence in studies with more sample size, such that the studies that includes more patients would have higher weight. It was later developed into Meta-regression Ordinary Least Square (OLS) model and more complex regression. Cheung (2015) incorporated Meta-analysis with a structural equation modeling approach.

Meta-analysis is widely used in medical research and health discipline as evidence in Cochrane library database. Mainly for the use of clinical trials and effects size. In psychological research, small studies typically produced contradicting results. Meta-analysis integrates the findings across such studies to reveal simpler patterns of relationships that underlie the research literature (Hunter & Schmidt, 2015). This generally suggests that the larger the sample size the more accurate the information. Many pharmaceutical companies have also benefited from using meta-analysis such as in drug testing.

Meta-analysis is a tool used to provide information to policymakers. Menkhaus and Lober (1996) suggested that existing studies environmental valuation can assist policymakers in comparing alternative land uses, prioritizing limited public funding, or altering current entrance fee structures. Most meta-analyses seek to review and synthesize extensive literature often with diverse findings. Meta-analysis statistical summaries can help to understand the reasons for that diversity. The primary use of meta-analysis as described by Smith and Pattanayak (2002) is taking stock of the results, summarize the literature for a benefit transfer model, and testing a hypothesis.

The purpose of the study is that by using Meta-analysis to combine original research analysis, generalize the results and estimate the relationship between dependent variables and a set of explanatory variables. This study research is based on literature review, so the accuracy of the result is primarily based on the analysis of original research. The meta-regression estimated the result of combined site studies would provide a more comprehensive set of information to better assist policymakers, particularly in the form of benefit transfer to be used in shaping policy context. Meta-analysis has become the standard methods of searching for general patterns from existing research (Randall et al., 2008).

The quality assessment needs to consider both the quality of the studies as well as the quality of the meta-analysis itself. The quality of individual studies is indicated by the study response rate and the quality of the meta-analysis is by scope test (Brouwer et al., 1999). Three types of validity are commonly investigated are criterion, content, and convergent (Boyle, 2003).

2.4.1 Meta-Analysis on Environmental Economics

Since the early 1990s meta-analysis has also been adapted in environmental economics (Zandersen & Tol, 2009). Initially, the primary objective of meta-analysis in environmental economics was to review works of literature composed of diverse empirical estimates. Now, meta-analysis has more applicable use in environmental valuation. Meta-regressions can generate summaries or benefit transfer function and linked the information to policy evaluation.

Smith and Kaoru (1990) use meta-analysis to summarize the benefit estimates derived from travel cost recreation demand models from 200 studies both published and unpublished. Using consumer surplus estimate from each study, it was possible to evaluate the influence of variables describing the site characteristics, the activities undertaken at each site, the behavioral assumptions, and the specification decisions. The results are used in BT analyses for policy evaluation.

There are multiple researches carried out in environmental economic field including hedonic valuation of air pollution (Smith & Huang, 1995); on elevated carbon (Curtis & Wang, 1998); carbon forest sink (Van Kooten et al., 2004); and benefit transfer estimated value for multi-function agriculture (Randall et al., 2008). In Sri Lanka, there are many micro-watershed programs both from government and private institution, Meta-analysis was conducted to assess the impact of watershed programs and find a linkage between performance of watershed development programs and people's participation (Joshi et al., 2005).

The meta-analysis published work on forest valuation includes 'forest recreational values' (Shrestha & Loomis, 2001); (Zandersen & Tol, 2009); the 'valuation of ecosystem services for mangroves' (Brander et al., 2012); 'passive use-value of Mediterranean Forest' (Otrachshenko, 2014); and watersheds function for tropical forest in South and Central America (Ojea & Martin-Ortega, 2015). The unit of measurement for forest valuation slightly varies depending on the object of the study. Many studies use a per hectare basis. For Shrestha and Loomis valuation of forest recreational values standardize the results to consumer surplus per person day. Zanderson and Tol (2009) study use a log of consumer surplus and consumer surplus per hectare as a dependent variable. Otrachshenko (2014) similarly presented the WTPs in marginal values for the Mediterranean forest. Shrestha and Loomis (2001) explored the meta-analysis model for benefit transfer in international outdoor recreation. Meta-analysis has been tested using in-sample convergent validity test for outdoor recreation database (Rosenberger & Loomis, 2000a) and using out-of-sample convergent validity (Shrestha & Loomis, 2003).

There are increasing uses of meta-analysis for benefit transfer due to growing demand and importance of environmental valuation. As a result, there are an increasing number of environmental valuation database such as ENVALUE database was launched in 1995, followed by the Environmental Valuation Reference Inventory (EVRI) database and others. The database help provided researchers, government officers, and consultants with greater access to primary studies. A list of meta-analysis on environmental valuation studies is summarized in table 2.1 below:

Table 2.1 Meta-analysis in Environmental Studies

Subject area	**Studies**
Agriculture	(Borisova-Kidder, 2006); (Randall et al., 2008)
Avoided deforestation cost	(Dang Phan, Brouwer, & Davidson, 2014)
Biodiversity	(Nijkamp, Vindigni, & Nunes, 2008)
Carbon	(Curtis & Wang, 1998); (Van Kooten et al., 2004)
Environmental valuation studies	(Gen, 2004)
Forest passive-use values	(Otrachshenko, 2014); (Lindhjem, 2007)
Recreation benefits	(Rosenberger & Loomis, 2000a) (Rosenberger & Loomis, 2000b); (Shrestha & Loomis, 2001); (Shrestha & Loomis, 2003); (Bateman & Jones, 2003); (Smith & Kaoru, 1990); (Zandersen & Tol, 2009)
Recreational fishing	(Sturtevant, Johnson, & Desvousges, 1995)
Groundwater quality	(Poe, Boyle, & Bergstrom, 2000);
Mangroves	(Brander et al., 2012)
Noise nuisance	(Kopsch, 2016)
Urban Pollution	(Smith & Huang, 1995); (Schwartz, 1994); (Van den Bergh, Button, Nijkamp, & Pepping, 1997)
Valuation of life estimates	(Mrozek & Taylor, 2009)
Visibility Improvement	(Smith & Osborne, 1996):

Subject area	Studies
Water quality	(Van Houtven, Powers, & Pattanayak, 2007)
Wetlands and Watershed services	(Ghermandi, Van den Bergh, Brander, De Groot, & Nunes, 2007); (Brouwer et al., 1999); (Woodward & Wui, 2001); (Brander, Florax, & Vermaat, 2006); (Ghermandi et al., 2007); (Enjolras & Boisson, 2008); (Joshi et al., 2005); (Ojea & Martin-Ortega, 2015)

The meta-analysis model for forest valuation is similar to meta-analysis for general environmental valuation whether be air, carbon, or forest. The difference is in the interpretation of unit of y as the dependent variable and the explanatory variables chosen. A set of explanatory variables chosen depends on which unit is the most useful and relevant for that study. In Shrestha and Loomis's (2001) 'Meta-analysis on recreational forest valuation', since the forest function is specified only to recreational use, a more detail analysis can be explored such as which types of activities. The explanatory variables can be tailor to a specific function such as by incorporating dummy variables for facilities and recreational activities that site offers such as bird watching, canoeing, or camping to find if it has a significant relationship with forest valuation.

The model of meta-analysis simple OLS regression, $y_i = \alpha + \beta x_i + \varepsilon_i$ with $\varepsilon_i = \mu_i + e_i$ where y_i is the dependent vector i observation, α is constant, β is coefficient or slope of x_i, and x_i is an explanatory variable of observation i. ε_i represent a random component or an error term. The dependent variable can be any values of interest. In Meta-analysis of carbon forest sink case (Van Kooten et al., 2004), y_i is a vector of s_i observation on sequestration costs from study i, x_i is an independent matrix of regressors, and ε_i is a vector of error terms associated with the cost of the dependent variable. The study analyses 981 observations from 55 studies of the cost of creating carbon offsets using forestry. The studied data were classified into forestry project types (forest management and programs); locations (tropics, North American Great Plans, the US cornbelt, and other regions); the scale of the study area. The result is shown in the cost of the entire project and calculates to a per hectare basis.

The Benefit transfer function as defined by Rosenberger and Loomis (2003) is

$$V_{Pj} = f_s(Q_{S\,|\,P_j}, \bar{X}_{S\,|\,P_j}, M_{S\,|\,P_j})$$

Where (V_{Pj}) stands for the value of policy site; (Q) represents a function of quantity or quality variables; (X) is a function of socio-demographic variables; and (M) is a function of methodologies.

Shrestha and Loomis (2001) estimated the economic value of outdoor recreation using benefit transfer from United States consumer surplus from 1967-1998. The value estimates are from 682 observations from 131 studies. The variables for Meta-analysis of recreational forest valuation are a dependent variable (consumer surplus); methodology variables (a qualitative variable set ‘1’ for stated preference and ‘0’ for revealed preference, the elicitation technique if open-ended question was used, and if payment card technique was used); site variables (a list of dummy variables that represent if the study site were national forest, if the recreation site has a lake, has a river, if the ownership is private or public, and separate into US forest service region); recreation activity variables (if such recreational activities were offered in each site include off-road driving, biking, snowmobiling, big game hunting, waterfowl hunting, fishing, rock climbing, and horseback riding); and Socio-economic variables.

Zanderson and Tol (2009) select different explanatory variables and have added species diversity index, tree age diversity index, year of study, latitude, and since a research is on European recreational forest many studies are from the same author so Zanderson capture that in a dummy variable, or if the study was from a thesis, size and average distance to the site, GDP (PPP) per capita, and population density. The total of 12 studies with 189 observations was used. The study more emphasis is placed on the authorship which shown a 10% significant in the log of consumer model, and year of study shown a 5% significant in CS per hectare model. At 5% significant relationship in the log of CS model population density and size. The variables that have a highly significant relationship in CS per hectare model are the size of the site study and the opportunity cost of time.

A meta-analysis study on the unit cost of avoided deforestation (Dang Phan et al., 2014) also found that there is a significant difference between the unit costs estimated for different locations. The data were collected from 32 primary studies, yielding 277 observations. The results show that unit costs depend significantly on cost features like estimation methodology, cost components, carbon accounting method, area size, alternative land uses and beneficiaries, time horizon, continent, and nation's agriculture economy. As the results can vary between different methodology suggested that there may be bias from using single study valuation.

2.4.2 **Pros and Cons of Meta-Analysis**

The benefit of using secondary data by transferring value from the study site to the policy site is more cost-efficient and less time-consuming. By using benefit transfer, researchers can compare the change between study case and policy case with some adjustment considering which variables affected the valuation. The estimated values reflect the changes in correlation with input adjustment on the characteristic of the policy site regression analysis. Coefficient estimated from the study site can be used to forecast or predict the benefits of an unstudied policy site. Though the obvious disadvantage for using secondary is that it adds another layer of error and can be as accurate as primary study be.

Shrestha and Loomis (2001) have identified three advantages of using benefit transfer with meta-analysis in their study in international outdoor recreation. First, it exploits the information from numerous studies to provide a more sophisticated layer of distribution of the study values. Second, the methodological difference can be controlled when calculating a value from the meta-analysis equation. Third, the researchers can explain the difference between the study site and the policy site by identifying the independent variables specific to the policy site. However, when using benefit transfer in an international context need to considered issues related to the socio-economic differences. In addition, there are differences in infrastructure, institutions and exchange rates that international benefit transfer must deal with. In Shrestha and Loomis research (2001), they have incorporated income differences, exchange rates and inflation in the study using PPP indices, and implicit price deflators. In general, Meta-analysis can correct for the distorting effects of sampling error, measurement error, and other artifacts that produce the illusion of conflicting findings (Hunter & Schmidt, 2015).

The popularity of meta-analysis in environmental studies arise from the increasing number of studies on environmental valuation, larger differences in valuation outcomes as a result of the use of different research designs (R. T. Carson, Flores, Martin, & Wright, 1996), and high costs of conducting environmental valuation studies which increase demand from policymakers to use transferable valuation results (Brouwer et al., 1999).

The main purposes of Meta-analysis are for research synthesis, hypothesis testing, and benefits transfer (Smith & Pattanayak, 2002). Meta-analysis as a systematic review has many advantages over narrative reviews (Arnqvist & Wooster, 1995). The result of meta-analysis can be applied as a reference point for development and compare with other studies. Meta-analysis acknowledges that all studies are not equally reliable, so it assigned weighing on sample size and categorical measures of reliability. Meta-analysis is also used to explain study-to-study variation by defining which methods and data set affected the reported results (Stanley, 2001).

Meta-analysis allows improved control of Type II statistical errors (Arnqvist & Wooster, 1995). It is less subjective than narrative reviews since it is based on a predetermined set of statistical procedures rather than individual interpretations of the data (Mullenm & Rosenthal, 1985). Meta-analysis helps to reduce selection bias and publication bias when picking selected studies that fit desired policy outcomes. It may also reduce the potential for autocorrelation due to learning effects and adjustment in methodology over time.

One of the disadvantages of Meta-analysis is that some of the detailed information from original studies are lost in order to generalize the information. The information can only be as good as the original data. Each study has its own different interpretation in terms of methods and its uses. In Dominican watershed study case (Veloz, Southgate, Hitzhusen, & Macgregor, 1985) focused the study on soil loss and sedimentation. Some solely focus on methodology and econometrics elements. Lee and Chun (1999) did a study on WTP if improve the quality for seasonal hunting. Unfortunately, a lot of these detailed analyses and findings are unable to capture in a meta-analysis.

Another disadvantage of meta-analysis is that it may incur publication-bias. Since most studies published only the significant study results while the insignificant study results may be left out (Brouwer et al., 1999). Multiple results from the same study are often treated as individual, independent observations without explicit testing for intra-study correlation (Wolf, 1986).

However, meta-analysis can offer quantitative methods to address pitfalls which can potentially lead to a misleading conclusion. Arnqvist and Wooster (1995) listed the disadvantage meta-analysis has, the most universal problem is the potential bias when the studies included in the meta-analysis are not representative of all studies conducted. This may result from biases in either publication rates or in selection or retrieval studies. Meta-analysis has also been criticized for a potential loss of information when a final research result is summarized by a single value. A further criticism on meta-analysis is a lack of uniformity across studies such that studies may differ in experimental condition, design or sampling unit which may affect the results.

2.4.3 **Combining Data in Meta-Analysis**

Meta-analysis is used as a systematic tool to pool data from a different source of studies. However, this method also occurs in various problems as well. The pooling data from across studies have a different definition of describing methodologies, different sites, and assumption combining them without any systematic review can be problematic.

Smith and Pattanayak (2002) suggested that to improve the quality of the analysis needs to view these arrays of information and identify any inconsistencies. The approach for selecting data for meta-analysis is grouped into three approaches: 1) includes all measure without adjustment to a common economic concept and attempt to control for differences in commodities with covariates; 2) adjust the measure to a common economic concept using information from the primary study or from other sources that attempt to match the original study, and only use those studies where common measures have been developed; 3) drop studies that do not fit some standard for comparable commodities and consistent measures. The approach of selecting data is not ideals but the second and third approach is more acceptable than the first. By eliminating some data such as outlier help improve the quality of the model.

The two different methods of non-market valuation are revealed preference (RP) which includes the travel cost model (TCM) and stated preference (SP) which includes contingent valuation model (CVM). In estimating meta-analysis involves combining data from two methodologies. Cameron’s study in 1992 shows that CVM and TCM can be combined. Cameron (1992) combined utility model TCM into CVM choice parameter to find a robust estimation of both sets of parameters. The joint model can be estimated using the cross-equation parameter. The research found that a discrete-choice direct utility function can be modified into an indirect utility difference function.

Follows Cameron’s study in 1992, Gonzalez et al. (2008) combined dichotomous choice CVM models with TCM models to test the consistency using a joint estimation method. The results were robust as all the parameters remain very close under two estimation approach.

Carson et al. (1996) compared contingent valuation estimates to revealed preference estimate using 83 studies with 616 comparisons. The summary result of the CV/RP ratio sample mean is 0.89 with a 95 percent confidence interval

Overall, the increased popularity of Meta-analysis research is triggered by increases in the available number of environmental valuation studies, and from the large differential outcome from those studies due to different research designs. Meta-analysis is less time-consuming and cost-effective, therefore the high cost of carrying out environmental valuation studies tend to increase policymaker demand for transferable valuation results (Brouwer, 2000).

CHAPTER 3

FOREST OVERVIEW

3.1 Forest Situation in the World

Forest, as defined by the Food and Agriculture Organization of the United Nations is *'an area of land covering at least 0.5 hectares containing trees taller than 5 meters and having more than 10 percent of the area covered by tree canopies'* (FRA, 2018)

Forest directly affected the livelihoods of more than 1.6 billion people. Forests and forests' product industry have valued over US$270 billion, which contributed to more than 20 percent trade in developing countries (Worldbank, 2008). Apart from trade contribution, forests also play a major role in our ecological system. Forests are home to at least 80 percent of the world remaining terrestrial biodiversity. Forest ecosystem contributes to a carbon sink, regulating global climate, maintain the fertility of the soil, protect watersheds, and reduce the risk of natural disasters such as flood and landslides. Forest's watershed services alone includes hydrological regulation, flow augmentation, flood control, ground water recharge, water quality enhancement, and soil conservation (Lele, 2009). The contribution of forest function to the ecosystem is vital and of public concern.

As the world population grows, the demand for wood, solid wood products, by-products, food, pulp, and paper grew correspondingly. Consequently, the demand for land and housing increased. Deforestation problems are caused by logging, agricultural clearance, building roads, and expanding of the urban area. Farmers cutting down trees and burning them for fertilization is the process called slash and burn agriculture which is very common, cost saving, and fast, but damages the environment. In regards to economic development, alternative land use that provides greater short-term benefit such as logging, agriculture, and cattle grazing resulted in deforestation, soil erosion, watershed degradation, and irreversible loss of biodiversity (Chase, Lee, Schulze, & Anderson, 1998). We are faced with situations of high deforestation across the world as illustrated in figure 3.1. United Nation's FAO figures shown an estimated 18 million acres (7.3 million hectares) of forest lost each year. Deforestation is a worldwide occurrence, but particularly tropical rainforests are targeted. If proceed with current deforestation level, NASA predicted that the world's rainforests could vanish in as little as a hundred years (Bradford, 2015).

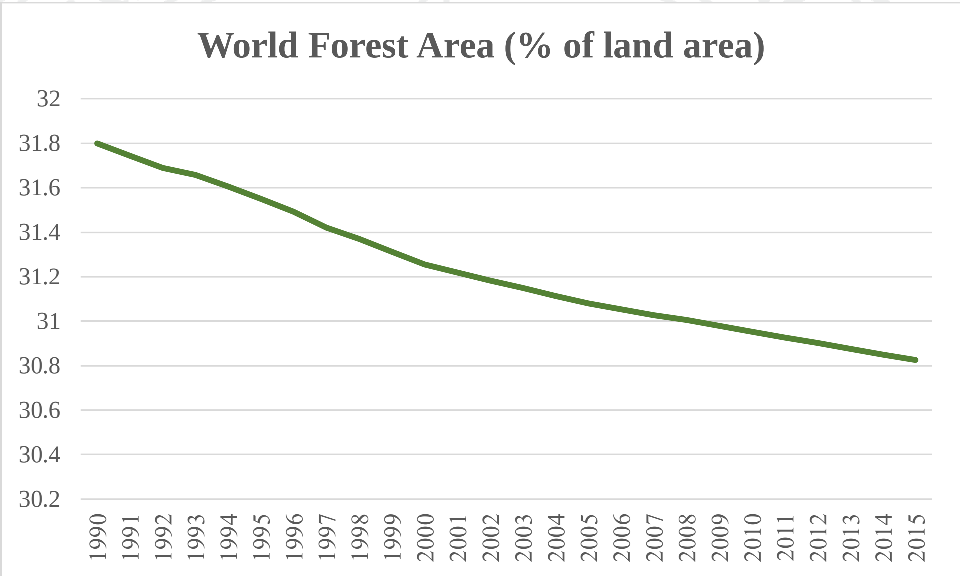

Figure 3.1 World Forest Area (% of land area)
Source: (Worldbank, 2017)

In table 3.1 show land use and forest area that between the year 2000 to 2015, Latin America & Caribbean forest area has decreased 2.6 percent; Sub-Saharan Africa 2.3 percent; South Asia about 1 percent; East Asia & Pacific, Europe & Central Asia decreased by about half a percent; and North America and the Middle East & North Africa decreased 0.3 percent. The overall figures from the year 2000 to 2015, the most concern is in Latin America and the Caribbean region. In Latin American, Brazil is home to 60 percent of the largest tropical rainforest which is the Amazon tropical rainforest. Brazil faces the largest annual net loss of forest area since 1990. Between 1990-2000 Brazil face with an annual change of -2890 thousand ha/year at -.51%

change and between 2000-2010 another -2642 thousand ha/year at -0.49% change (FAO, 2010).

Table 3.1 Land Use and Forest Area by Region

	Land Area (sq. km thousands)	**Forest Area (% of Land Area)**		**Permanent Cropland (% of Land Area)**		**Arable Land (% of Land Area)**	
	2015	**2000**	**2015**	**2000**	**2015**	**2000**	**2015**
East Asia & Pacific	24387	25.7	26.3	1.9	2.6	9.9	9.5
Europe & Central Asia	27441	37.5	38.0	0.8	0.7	12.8	12.3
Latin America & Caribbean	20042	48.9	46.3	1.0	1.0	7.0	8.6
Middle East & North Africa	11236	1.8	2.1	0.7	0.9	4.8	4.7
North America	18241	35.7	36.0	0.5	0.4	12.1	10.8
South Asia	4772	16.6	17.5	2.4	3.4	44.3	43.3
Sub-Saharan Africa	23618	28.0	25.7	1.0	1.2	7.6	8.8
World	**129737**	**31.3**	**30.8**	**1.1**	**1.3**	**10.8**	**10.9**

Source: (Worldbank, 2017)

Half a decade ago, Southeast Asia has closed forest area of 91 million hectares which represent half of the total land area (FAO, 1976) while the forest area in 2015 remains only at 26 percent (Worldbank, 2017). The report of this sub-region countries comprises of Cambodia, Laos, Myanmar, Thailand, and Vietnam (include the Vietnam Democratic Republic) has forest area of 93 million ha in 1990, 91.6 million ha in 2000, 90 million ha in 2010, and 88.4 million ha in 2015.

3.2 Forest and Development in Thailand

Thailand is in the Southeast Asia region and has a total area of 514,000 sq. km. (51.4 million hectares). Similar to the rest of the world, the once dense forest cover has shifted for more agricultural land and developing. Forest land has also been suffered from shifting cultivation. The forest cover in Thailand fifty years ago was almost 50 percent of the land cover, more recently have dropped down to 30 percent. The agricultural land in 1961 was 22.8 percent compares to 43.3 percent in 2015 (Worldbank, 2017)

In the report on forest resources in the Asia and the Far East region (FAO, 1976), the area of closed forest in Thailand is 24.5 million ha, 0.7 per capita, for agricultural use is 11.4 million hectares, and the rest 15.6 million hectares are for other purposes. The total land area comprises 51.5 million hectares and the forest area being 47.6% of total land area. The main use and export of forest are for timber, paper and pulp, and furniture.

3.2.1 **The Evolution of Forestry in Thailand**

Over a century ago, Thailand was abundant with forest and people can use and exploit the use of forest freely without permission. Teak wood (*Tectona grandis Linn.f.*) is well-known in the west for high-quality wood and valuable. After the British Army have invaded Myanmar and India, they started logging and import teak cause forestry to deteriorate rapidly. At the same time, once people realized that Northern Thailand is abundant with expensive wood, many parties want to export which is the start of extensive logging and the cause of deforestation in this area.

The government became aware of this problem and began managing the forest more systematically. Thereby, forest tax was started in 1830 (B.E. 2372) and any forest logging needs to ask for permission first. Many legislations were adjusted after that time until the Royal Forestry Department was established in 1896 (B.E. 2439)

After the establishment of the Royal Forestry Department, the forestry in Thailand can be split into four periods (Ruangpanich, 2013). The **Classical or traditional forestry** in 1896 – 1951 (B.E. 2439-2494), during this time forest main focus is on timber exploitation management; **Multiple-uses forestry** in 1952 – 1981 (B.E. 2495-2524) which focuses on soil, river source, animals and national park; **Social or Community Forest** in 1982 – 2000 (B.E. 2525-2543) which focuses on the involvement of the community living nearby the forest; and **Urban and Private Forestry** from 21 century (B. E. 2544) onwards, which is the modern forest management (Ruangpanich, 2013).

Similarly, Thailand faced the problem of high deforestation rate in the past century. For Thailand and other developing countries, forest values were only considered mainly for exports. After became more aware of forest use and its impact on the community, the Ministry of the Interior established the Royal Forest Department to conserve forests and control revenue from the teak forests in northern Thailand by 1896. The Royal Forest Department was established to conserve forests and control revenue from the teak forests in northern Thailand. By 1899 all forests were declared as government property and all logging without payment to the Royal Forest Department was prohibited.

Table 3.2 Thailand Land-use Pattern by region in 2001

Region	Forest %	Farm holding Land %	Unclassified %
North	54.0	26.4	19.6
Northeast	15.0	55.0	30.0
Central	27.1	30.9	33.0
Southern	22.5	43.4	34.1
Total	**31.4**	**40.9**	**27.7**

Source: Based on Agricultural Statistics of Thailand in 2004 (Ruangpanich, 2013)

In 2001, the land use of the country was divided between agriculture or farm holdings (41 percent), forest (31 percent), and unclassified area (28 percent). This pattern was the result of the rapid expansion of agriculture on what was previously forest land. There are significant differences in the land-use pattern by region; the Northern region still has more than 50 percent under forest cover, while the other regions are predominantly agricultural. It is noteworthy that about one-third of the total land in the other three regions remains "unclassified" which includes urban and peri-urban areas, infrastructure, and degraded areas which were in the past were under forest cover (ICEM, 2003).

The major causes of deforestation in Thailand are from population growth, agricultural policy, land ownership policy, and illegal logging. As the population grows there is more demand for food, and much of the forest land was cleared to increase food production. This is also evident in the densely populated region in the northeast region of Thailand. Governmental officials in charge of protected areas have contributed to deforestation by allowing illegal logging and illegal timber trading. This is evident in places such as large protected swathes of northern Nan Province that were formerly covered with virgin forest and that have been deforested even while having national park status.

In 1945, the forest cover in Thailand was at 61 percent of the total land area. Within sixteen years the forest cover was reduced to 53.33 percent in 1961 (FAO, 2009). According to the World Bank data (2017), the percentage of forest area in Thailand is as low as 27 percent in 1990. Then climbed up to 33.3 percent in 2000 before another drop in 2005 to 31.5 percent as shown in figure 3.2. For the last decade, the forest area gradually increases to 32 percent in 2015. In terms of per hectares, in 1990 the forest area started 14 million ha (140,050 sq. km). In the year 2000 the forest area is highest at 17 million ha (170,110 sq. km), then drop to 16.1 million ha (161,000 sq. km) and in 2015 Thailand forest area is at 16.4 million ha (163,990 sq. km). In a separate report (FAO, 1976), forestry in Thailand as in 1961-64 is at 24.52 million ha or about half of the total land area, which means within 30 years from the 1960s to 1990s the total forest loss was 10million hectares and this is Thailand alone. In the

1970s, the estimated commercial forest areas in Thailand is 19.7 million hectares, and of that 18.7 million hectares are in use, which is 95% of all operable closed forest are used for commercial logging. The inoperable closed forests are 4.8 million hectares and total forest area in Thailand at the time is 24.5 million hectares.

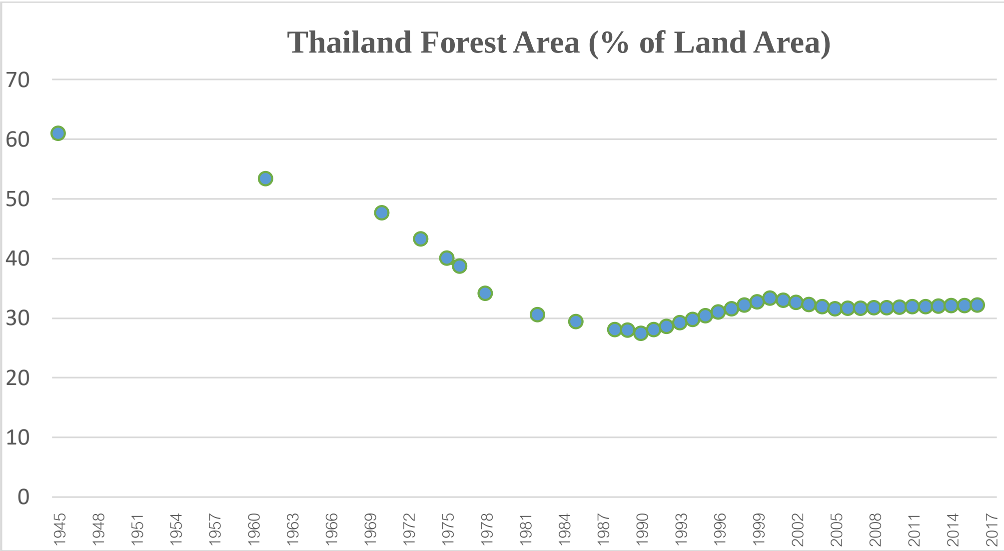

Figure 3.2 Thailand Forest Area (% of land area)
Sources: (FAO, 1976, 2009; Hirsch, 2009; Lakanavichian, 2006; Worldbank, 2017)

3.2.2 **Forest Law and Policy in Thailand**

The Thai "Forest Act, B.E. 2484 (1941) was passed and in force as of 1st January 1942 (B.E. 2485). The law protects forest defined by land which has not been taken up or acquired by any other means under the Land Law. The law prevents unauthorized logging. The measure was taken to protect timber including teak and other hardwoods including trees, brushwood, creepers, and imports. Also cover "forest products" defined by all things that are naturally exist in the forest which are timber and all parts thereof, charcoal, wood oil, resin and all other things derived from trees or timber; all kinds of plants, mushrooms and things derived therefrom; birds' nests, lac, bee-hives, honey, bees-wax and guano; rock, minerals which are not prescribed in accordance with the Law on Mining and also includes charcoal (ILO, 2010; Thai Law Forum, 2010).

The Law that protects Thai forests and by violating them are considered a criminal offense are: Forestry Act 2484; National Park Act 2504; National Forest Act 2507; and Wildlife Conservation Act 2535. Under forest Act, B.E. 2484 (1941) the fine for deforestation offense punished the offender of imprisonment not exceeding five years, and or fine not exceeding 50,000 baht (US$1500), and or both. If such crime committed for the area over 25 rai (4 hectares), the punishment for the offender is imprisonment of 2 – 15 years, and fine of 10,000- 100,000 baht (US$300 - US$3000). The fine for deforestation offense was calculated fixed-sum.

The Thai government has pressed concern for the environment at the end of 1961 (B.E. 2504) during that time, Field Marshal Sarit Thanarat acted as Prime Minister (Jarusombat, 2008). During that time the economic development plan for the country was written with environmental concerns in mind.

In accordance with the National Economic and Social Development Plan, the forestry policy has been steering more towards sustainable use of the forest. The first issue of the plan in 1961 - 1966 (B.E. 2504-2509) include a policy on forest reserve and land classification, the upstream watershed protection, recreational forest management, wildlife conservation, and forest plantation.

The national forestry policy ineffective as of 3rd December 1985 came to conclusion with 20 topics, the fourth topic stated that the forest cover in Thai should be at least 40 percent of the land for two purposes: (1) for forest conservation for the environment include water, soil, plant species, endangered animals, prevent natural disaster that are from flooding, soil erosion, as well as for education and recreational purposes. The Conservation forests titled for 15 percent of the land; (2) forest for economic development which set for 25 percent of the land. In the 1960s the total forest area was at 47 percent, and recorded 27 percent in 1990, and more recently at 32 percent in 2015 which means more efforts need to be done in order to meet the policy guidelines.

There are many criticisms on how the justice system is influenced by the rich and those who are powerful versus humble villagers or farmers. In the case of mushroom picking incident in 2017, a couple of villagers entered a national park without permission and pick mushroom for commercial purpose was sentenced to be imprisoned for 15 years, after repeal the court reduced to 5 years. Some view as the punishment was too harsh. However, the court decision is based on the invasion of the national park, degraded the national forest, illegal logging of 700 tresses, and possession of teak wood which is forbidden. On a more recent case which evokes Thai community is illegal hunting and killing a Black Panther in 2018. A case which people demand justice through the media and social media and the interest of this case has shown a reflection of social values in Thai society.

3.3 Forest Classification by Latitude

Forest roughly covers around one-third of the world's surface in a different part of the globe and different terrain and weather. There are three broad forest zones according to the distance of the area to the equator, which 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 is not much seasonal change, consistent rainfall and the trees are green all year round. The area with distinct seasonal change as well as rainfall is most likely a deciduous forest.

The earth equator is the latitude at 0° (zero degrees) at the center of the earth dividing northern and southern hemispheres. The circles of latitude that furthest from the equator are Polar Circles which called the Arctic Circle and Antarctic Circle. The other two circles closer to the equator dividing the plane are the Tropical Circles, with the Tropic of Cancer at the top and Tropic of Capricorn at the bottom.

The area near the equator between the tropic of Cancer and Tropic of Capricorn is considered **Tropical forest zone**. This includes many tropical rainforest and evergreen forests. 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 **Temperate forest zone**, which includes North America, and European countries. The area above the Polar Circles, which includes Finland and some part of Russia is called **Boreal forest zone**.

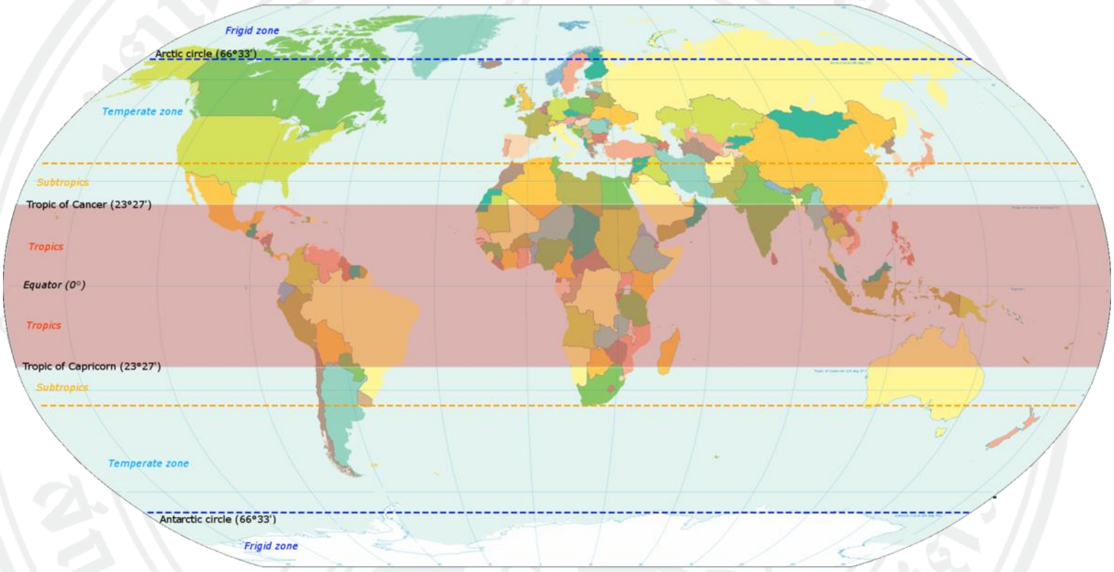

Figure 3.3 World Map with Equatorial Zone
Image Credit: (KDVP, 2003)

3.3.1 **Forests in Tropical Zone**

The tropical zone between the equatorial zone between the Northern Tropic (Tropic of Cancer) and Southern Tropic (Tropic of Capricorn), generally have warm temperature all year. The tropical climate is home to many evergreen forests including tropical rainforests.

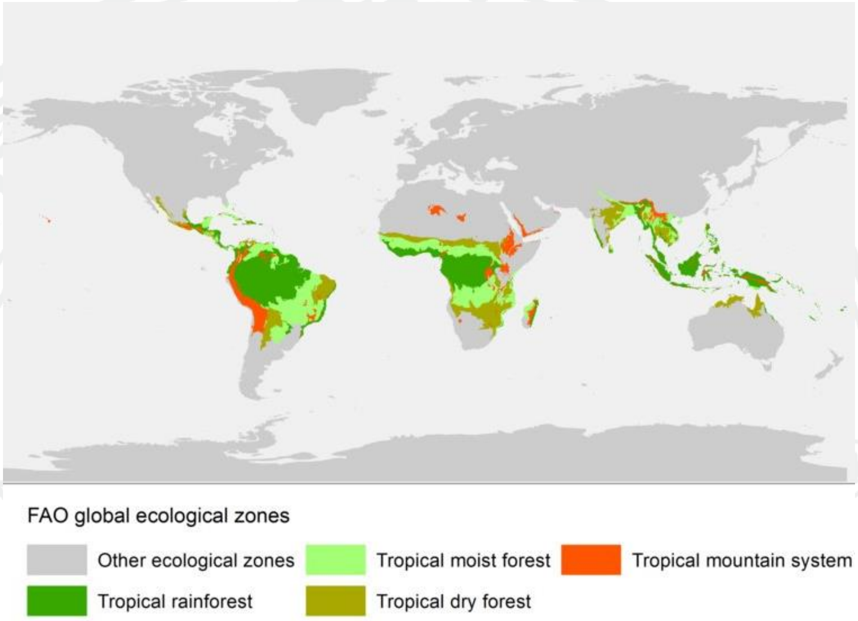

Figure 3.4 Map of Tropical Forest
(Image Credit: FAO, 2010)

The different subcategories within the tropical forest are Tropical Evergreen Forest with consistent rainfall all year round (no dry season); Tropical Seasonal Forest with evergreen vegetation but with a short dry season; Tropical Dry forest has a long dry season in which trees lose leaves. More specific are Montane or Tropical Cloud Forest receives most precipitation from mist or fog that rises, and they are mostly coniferous trees. Cloud forests are found in Central America, South America, Africa, Southeast Asia, and the Caribbean. Tropical and Subtropical Coniferous Forest are coniferous trees adaptive to a dry and warm climate. Conifers refer to cone-bearing seed plants which are pines, spruces, firs, larches, yews, cedars, hemlocks, and redwoods. Conifers can be trees or shrubs. Sub-tropical Forest includes a tree that adapted to resist summer drought

3.3.2 **Forests in Temperate Zone**

Temperate forests occur between the Polar Circles and Sub-Tropics Circles latitude. The forest covers North America, Europe, northeastern Asia (China and Japan), and some part of Russia. The temperate region has distinct season warm summer, spring, fall, and cold winter. The temperature can range from -30 to 30°C (or -22 to 86 F). Therefore, the majority of the forests in this zone are deciduous forest or leaf-shedding. The annual rainfall is around 75-150cm (30-60inches).

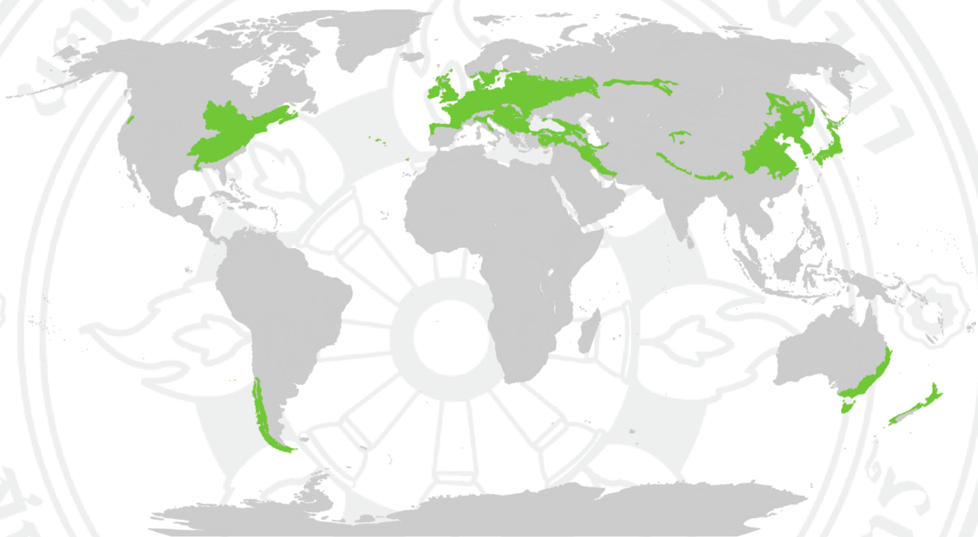

Figure 3.5 Map of Temperate Forest
Image Credit: (Terpsichores, 2010)

Subcategories within temperate forests are Moist Coniferous and Evergreen Broad leave Forest with mild wet winters and dry summers climate; Dry Coniferous Forest has low precipitation and usually at high elevation; Mediterranean Forest: located south of temperate regions around coast, the tree is mostly evergreen with high rainfall; Temperate Deciduous Forests consists of trees that shed their leaves every year; Temperate broadleaf and mixed Forests has an even distribution between evergreen trees and deciduous tree; Temperate broad-leaved Rainforest is evergreen forest with mild, frost-free winters, and high rainfall throughout the year. The temperate rainforest in this zone also receives heavy rainfall, second to tropical rainforest.

The tree found in the temperate forests are redwood, oak, ash, maple, birch, beech, poplar, elm, and pine. The diversity of plants species is less than tropical rainforest with average 3-4 species per square kilometers. The animals that live in the temperate forest are adapted to both cold winter and warm summer.

3.3.3 **Forest in Boreal Zone**

Boreal forests also called taiga, or Snow forest are found between 50 and 60 degrees of latitude in the sub-Arctic zone. This area includes Siberia, Scandinavia, Alaska, and Canada. Trees are coniferous and evergreen. The season is also distinct with short warm summer (between 50 – 100 days) and long cold dry winter. The temperature range between -40 to 20°C (-40 to 68° Fahrenheit). The precipitation is around 40-100 cm (15-40 inches) annually, though the tree and soil get some moisture in the form of snow. The soils are poor nutrient and thin layer and acidic due to falling pine needles. Evergreen conifers with needle leaves that can stand the cold, like pine, fir, and spruce trees, live here. Animals that live in these forests can withstand long periods of cold temperatures and usually have thick fur or other insulation such as moose, bears, lynx, wolf, deer, wolverines, caribou, bats, small mammals, and birds.

There are two major types of the boreal forest: Closed-canopy forest in the southern part consist of closely spaced trees with mossy ground cover, and Lichen woodland or sparse taiga forest common in the northern part with trees that are father-spaced and lichen (algae) ground cover.

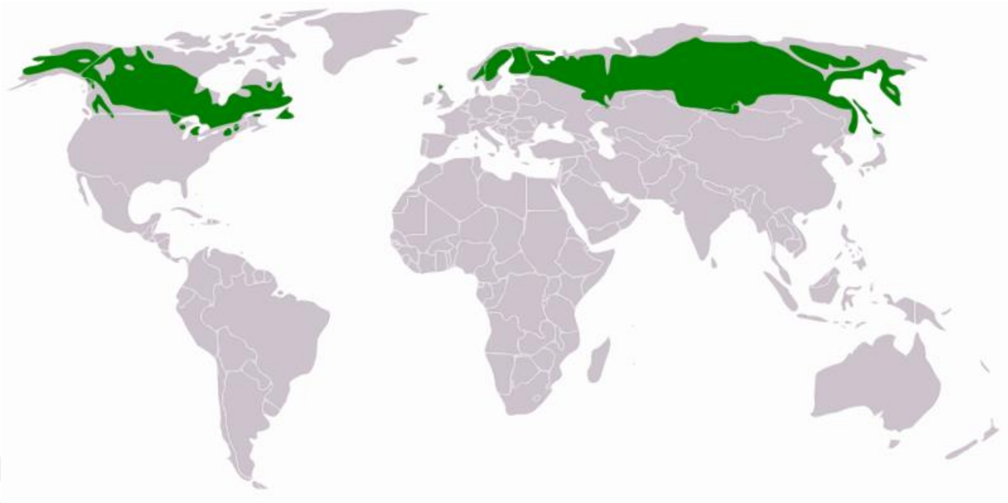

Figure 3.6 Map of Boreal Forest
Image credits: (Terpsichores, 2010)

Forest classification by latitude reveals that within the same groups of latitude zone has similar weather and climate throughout the year. The types of forest are largely determined by geographic locations and the weather. Therefore, forest classification by latitude is hypotheses to have a significant influence on forest values. For example, recreational value of forest of countries with distinct winter and summer may be less than a forest in the tropical zone due to limited visit throughout the year versus all-year-round visit. Forests in the tropical zone are scientifically effective at absorbing carbon per ton, therefore such valuation might be reflected on forest value in carbon sequestration costs. However, when looking at the geographical location specifically, many of the developed countries are in the temperate forest which may result in higher forest values because of forest values determined by people's income, WTP, and perceptions.

In this research, the latitude and longitude of the study site, for tropical forest and the subtropical forest is set between the equator to 34°north and 34°south; temperate forest between 35 ° and 55 ° north and south; and the boreal forest is the area above and below 55 °.

3.4 Forest Classification by Tree Species and Biome

Biomes are determined by climate, geographical location, as well as other factors such as plant structures, leaf types, plant spacing (forest, woodland, savannah), and climate (Van der Ploeg et al., 2010). There are many names and classification for forest types depend on which source to reference from. This section will give an overview and brief definition of different biomes. For data analysis and standardized purpose, biome terms are heavily based on The Economics of Ecosystems and Biodiversity (TEEB)'s classification.

Some of the example on classifying biomes based on its location and origins are named based on the nearby environment such as forests found near the ocean is called "coastal forest"; a forest that is high in the mountain is called "cloud forest", "montane forest", or "alpine forest" (Grebner, Bettinger, & Siry, 2013). Forest in a plain flat area or steep terrain. Forest in an arid environment. Forest in standing bodies of water called 'Swamp forest', to name a few. Forest in a moist environment, humid environment, forests that adapted itself in snowing winter.

Figure 3.7 shown another approach of mapping the terrestrial through characteristic, location, and its biome, which is also largely based on the forest by latitude. This includes Tropical desert, Tropical shrubland, Tropical mountain system, Tropical dry forest, Tropical moist forest, Tropical rainforest, Subtropical desert, Subtropical steppe, Subtropical dry forest, Subtropical humid forest, Temperate desert, Temperate steppe, Temperate mountain system, Temperate continental forest, Temperate oceanic forest, Boreal mountain system, Boreal tundra woodland, Boreal coniferous forest, and Polar.

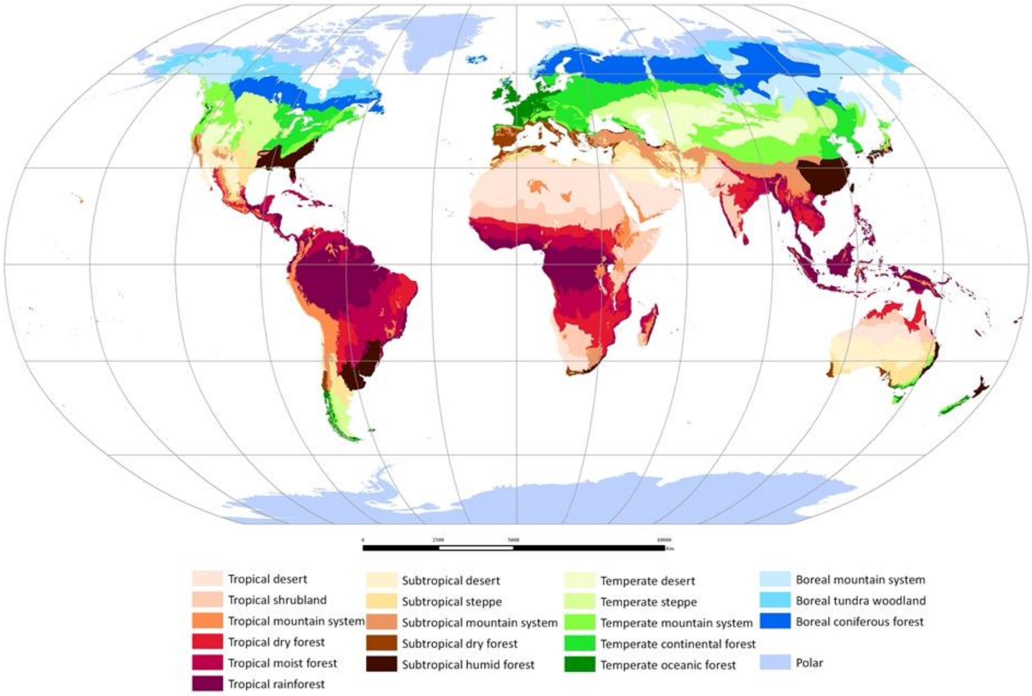

Figure 3.7 Global Ecological Zones
Source: (FAO, 2010)

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

3.4.1 **Deciduous Forests**

Mixed deciduous forest

Mixed Deciduous forest or temperate broadleaf and mixed forest shed leaves during the dry season. The broadleaf trees in this biome include oaks, beeches, maples, or birches. The term “mixed forest” includes coniferous trees as a canopy component. A moderate annual temperature is 3 to 16°C (37 to 60° Fahrenheit). It can be grown at elevation 50-800 meters above sea level.

Dipterocarp forest

Dipterocarp, Dry Dipterocarp, or Lowland Dipterocarp forest refers to trees in *Dipterocarpaceae* family and can be found in the tropical region on the world, but particularly in Southeast Asia. Dipterocarps are a family of hardwood, similar to teak. It can be grown at elevation 50-1300 meters above sea level.

3.4.2 **Evergreen Forests**

Tropical rainforest/ Tropical evergreen forest

The tropical rainforest exists particularly in the lowland area nearest to the equatorial zone which is the latitude of 10°N and 10°S of the equator specifically have the hot and wet climate all year round. Rainforest comprises of tall trees in a region with an average annual rainfall of more than 200 cm per year with mean monthly temperatures over 18 degree Celsius (64 Fahrenheit) (Blue Planet Biomes, 2010). The tropical rainforest has high biodiversity, with one square kilometer (0.6 miles) can have up to 100 different tree species. They provide many benefits from a source of wood, forests' byproducts, medicine use, recreation, biodiversity, ecosystem, and carbon sequestration. Tropical rainforest regions include Central America along, Africa, Madagascar, West part of India, Southeast Asia, New Guinea, and some part of Australia.

The largest tropical rainforest, the Amazon rainforest which major part cover Brazil, Colombia, Peru, and minor part of forest extend to Venezuela, Ecuador, Bolivia, Guyana, Suriname, and French Guiana. Amazon tropical rainforest has a total area of 5.5million sq km. (550milion ha). Other tropical rainforests in the equatorial region are the Atlantic Forest which covers 1,315,460 sq km. in Brazil, Paraguay, and Argentina; the Madagascar lowland covers 112,600 sq km. in Madagascar; the Ituri Rainforest covers 63,000 sq km. in the Democratic Republic of Congo; the Hawaiian Tropical Rainforest covers 6700 sq km.in the Hawaiian Islands; the Daintree Rainforest covers 2600 sq km. in Australia; and Harpan Rainforest covers an area of 985 sq km. in Sumatra. Some of the worth noted rivers that flow through the tropical rainforest are the Amazon, Mekong, Orinoco, and Congo.

Cloud forest, Water forest, or Montane forest

Cloud forest is generally in tropical or subtropical evergreen moist forest. Usually with large tall trees and situated in high elevation. The moisture comes from the saturated fog in the atmosphere from evapotranspiration. The environment in which this forest grows is similar to tropical rainforest, apart from the cloud forest usually have higher elevation.

Hill evergreen forest

Hill evergreen forest is an evergreen forest that can be found 1000 meters above sea-level. It is less dense than Tropical Evergreen forest. The climate is quite cold. Trees are mainly shrubs mixed with some pines. The hill evergreen forest is also important to the preservation of water. Some of hill evergreen forests in Thailand are Phu Luang and Phu Kradung in Loei, Khao Yai in Nakhon Nayok and Khao Luang in Nakhonsritamarat.

Dry evergreen forest

Dry evergreen forest is the indigenous forest of the coastal seaboard of southeast India. The vegetation in this forest are trees, shrubs, lianas, epiphytes, herbs, and tuberous species. The elevation for the dry evergreen forest is between 100-800 meters above sea level.

Pine forest or Coniferous forest

Pine Forest or Coniferous forest consists of pine trees largely in a temperate forest. Some species of pine grow to be 3-80 meters, the majority of a pine tree are 15-45 meters tall. Pine forest grows in elevation between 200-1800 meters above sea level.

Wetland, or Swamp forests

Swamp forest, or forest near a wetland, many swamps occur along large rivers. The water of a swamp can be freshwater, brackish water, or seawater. The freshwater swamp is also called a flooded forest. Swamp is in tropical, subtropical, temperate, and boreal climate zones. Some of the large swamps are the one along Amazon River, the Mississippi in USA, and Congo. Thailand also has swamp along Chao Praya River.

Wetland in general (which are not salt water) floodplains, swamps, or marshes are classified under inland wetlands under TEEB guidelines.

Mangroves

Mangrove is a shrub or small trees that grow in coastal saline or brackish water. It can be found in the tropics and sub-tropic climate specifically between latitudes 25° N and 25° S the highest mangrove cover in the world is Indonesia with 2.3 million hectares (23,143 sq. km.), followed by Brazil and Malaysia. Now mangroves also face the problem of deforestation as many villagers have converted into shrimp farming as it is high demand and receive more profit. Mangrove forests are home to a large variety of fish, crab, shrimp, and mollusk species. In TEEB classification mangroves and tidal marsh ecosystems were included in ‘coastal wetlands’ due to its distinguishing services and socio-economic importance (Van der Ploeg et al., 2010)

Savannah or grassland

Savanna or savannah is a mixed woodland grassland with shrubs and isolated trees. Occurs in a very hot dry area, mostly in Africa. It can also be found in South America, Australia, India, Myanmar, and Thailand. Savanah covers about 15% of the world cover.

Forest classification by species is summarized in Table 3.5 with climate and geographic location of Thailand forestry in mind. In figure 3.9 show a forest summary by zone, temperature and moisture level.

Table 3.3 Forest Classification

Deciduous Forest	Mixed deciduous forest
	Dipterocarp forest
Evergreen Forest	Hill evergreen forest
	Pine forest
	Dry evergreen forest
	Tropical rainforest, moist Evergreen forest, Tropical cloud rainforest Swamp or wetlands

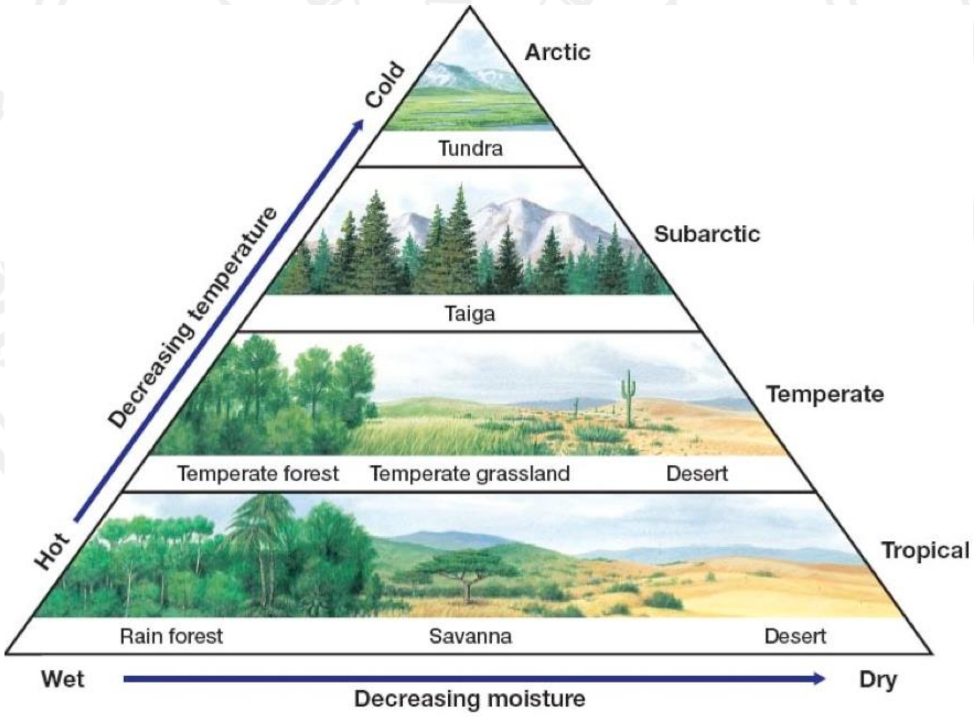

Figure 3.8 Forest Summary by Zone, Temperature and Moisture Level

Source: (FRA, 2015)

Forest classification by trees species is expected to have a significant impact on forest values. As the same group of tree species is expected to have similar values such that teak is considered as expensive wood in Europe, America, and Asia with some value adjustment based on demand and supplies. Forest value of savanna would value similarly throughout Africa, with all else hold equals. Rainforest in Amazon would serve in a similar function as the rainforest in South-East Asia, the adjustment would be on other characteristics such as the size of the forest, population demographics, socioeconomics, and cultural values.

The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative focused on economic benefits of biodiversity, cost of biodiversity loss, and ecosystem degradation (McVittie & Hussain, 2013). In the TEEB report (Van der Ploeg et al., 2010) has identified the biome and ecosystem classification scheme into 12 main biome types. However, ten biomes are included global estimates of ecosystems values (De Groot et al., 2012) and only five biomes that is forestry related (not including multiple ecosystems) are included in this study. The biomes included in this study are Forest (Temperate, Boreal, and Tropical); Wetlands (Inland and Coastal); Woodlands; Grassland; and Cultivates, details as shown in table 3.4 (Van der Ploeg et al., 2010). The biomes in TEEB classification that are out of the scope of this study are Marine/ Open Ocean; Lakes/Rivers; Desert; Tundra (non-wooded); Mountain or Polar; and Urban.

Table 3.4 TEEB's Biomes and Ecosystem

Biomes	**Ecosystems**
Forest (Temperate and Boreal)	Temperate rain or evergreen forest
	Temperate Deciduous forest
	Boreal/Coniferous forest
Forest (Tropical)	Tropical rainforest
	Tropical dry forest
Wetlands (Coastal)	Tidal Marsh
	Mangroves
	Salt water wetlands (unspecified)
Wetlands (Inland)	Floodplains
	Peat wetlands
	Swamps and Marshes
	Fresh water wetland (unspecified)
Woodlands (Shrubland/ Dry land)	Heath land
	Mediterranean Scrub
	Tropical woodlands
	Other woodlands
Grassland/ Rangeland	Savanna etc.
	Steppe
	Other tropical natural grasslands
	Temperate natural grasslands
	Grasslands (unspecified)
Cultivates	Cropland (arable land)
	Pastures
	Orchards/agro-forestry, etc.
	Plantations
	Rice paddies, etc.
	Aquaculture
Multiple ecosystems	Multiple ecosystems

3.5 Forest Ecosystem Services

Forest is one of the earth environmental resources, it is home for multiple species of animals and plants. It acts as a protector against natural disaster and help keeps nature in balance, controls water flow, add nutrient to soil, produces fresh lean air, and can be view as a scenic for our recreational activities. Forest product can be considered for direct use such as wood and timber, and indirect use such as forest byproducts, medicine, and ecological contribution.

Costa Rica created Forest Law No.7575 in 1996. The Law was developed from years of forest polices which introduces paying owners of forested property, or property in the process of reforestation, to compensate for the environmental services provided by their activities in general (Reyes, Segura, & Verweij, 2001). Forest Law No.7575 recognized four environmental services provided by forest ecosystem which are mitigation of greenhouse gas emission; hydrological services, including the provision of water for human consumption, irrigation, and energy production; biodiversity conservation; and provides scenic beauty for recreation and ecotourism (Pagiola, 2008).

Since then forest ecosystem services have been classified into more structured categories. The Millennium Ecosystem Assessment (MA) was called for by the United Nation in 2000 and initiated in 2001. The objective of MA was to assess the consequences of ecosystem change for human well-being as well as scientific study for an action plan to enhance the conservation and sustainable use of the ecosystems.

Forest Ecosystem as defined by Millennium Ecosystem Assessment is categorized into four types of ecosystem services which are cultural services; provisioning services; regulating services; and supporting services (Adamowicz, 2017)

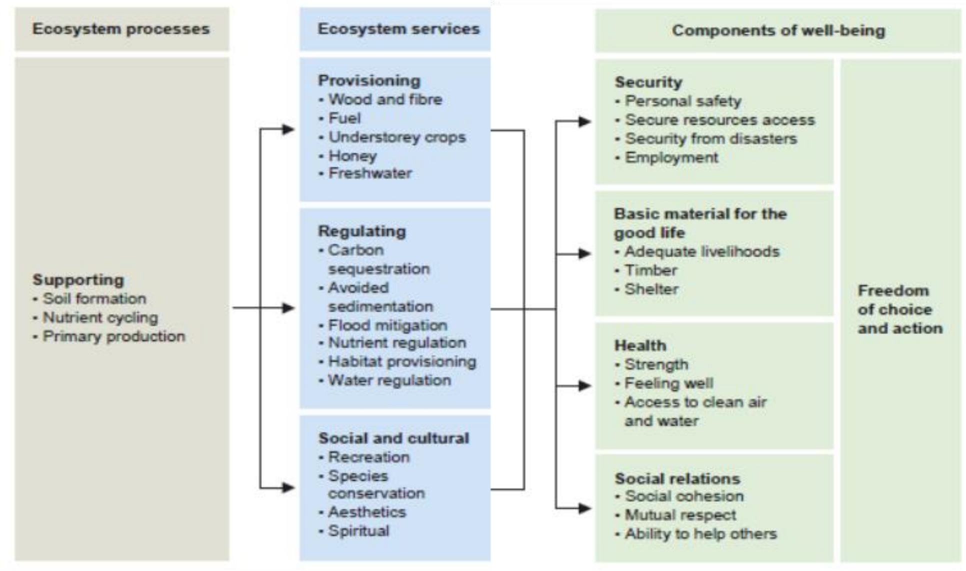

Figure 3.9 Millennium Ecosystem Assessment

Provisioning services are the tangible and direct products extracted from the forests to be used or sold such as logs, woods, fiber, and fuel. This also includes forest byproducts such as ginseng, herbs and medicinal used plants, and freshwater fish or crustacean that grows in a pond.

Regulating services include the ability of the forest to store carbon, reduce erosions, improve water quality, and reduce the effects of floods. Steep land planted in trees will also have less erosion than if it were in the pasture.

Cultural services are benefits provided by planted forests that are non-material and has social values. Cultural and social services include recreation, species conservations, aesthetics, and spiritual enrichment. Many national forests provided the opportunity for a range of activities such as hiking, walking, horse riding, hunting, camping, canoeing, and other sports.

Supporting services is a biological and physical process in a forest drive the other three services. For example, supporting service includes soil formation, nutrient cycling, water regulation, and oxygen production.

Similarly, The Economics of Ecosystems and Biodiversity (TEEB) Foundations describe the ecosystem service classification into four main categories which are provisioning services; regulating services; habitat services cultural services and 22 services which can be further explained in table 3.5 (Van der Ploeg et al., 2010)

Table 3.5 Ecosystem Service Classification and Services

Ecosystem Service	Services
Provisioning services	1. Food 2. Water 3. Raw materials 4. Genetic resources 5. Medicinal resources 6. Ornamental resources
Regulating services	7. Air quality regulation 8. Climate regulation 9. Moderation of disturbance 10. Water flow regulation 11. Waste treatment 12. Erosion prevention 13. Soil fertility maintenance 14. Pollination 15. Biological control
Habitat services	16. Nursery service 17. Genepool Protection
Cultural services	18. Aesthetics information 19. Recreation 20. Inspiration for culture and art 21. Spiritual experience 22. Cognitive development

CHAPTER 4

DATA & METHODOLOGY

4.1 Data

4.1.1 Data Collection

The database is a ‘snapshot’ of available valuation studies from available sources (McVittie & Hussain, 2013). Nevertheless, with a substantial number of studies from reliable source should represent the approximate values of the ecosystem with limited time and budget constraints. The quality of valuation estimates largely depends on the quality of the database gathered. The database used in this meta-analysis studies is from a collection of economic valuation of forest ecosystem from 62 countries across the globe. The information was gathered from 81 original research studies, with a total of 301 observations.

In selecting original research study cased in this study, should be relevant and reflective of the current situation. The research must be conducted from the year 1990 onwards or from The Ecosystem Services Valuation Database (ESVD) (Van der Ploeg & De Groot, 2010) the validation year must be from 1990 onwards. The range of research validation year is between 1990 and 2014 (as according to TEEB, 2010). The range of research study by publication year is from 1982 to 2017.

The criteria for selecting research studies are based on completeness of the data and whether additional information can be found based on the information of the site given. Most important the original research studies must indicate monetary value attached to the size of the study site such as dollars amount per hectare, the relevant population affected, methodologies used, and also a general area of the site location.

The original case studies rarely give a complete database. The other supporting data used are statistical data from electronic databases. For examples, many studies did not state the types of forest or biome, however, given the site specification, further information can be found through the country's FRA report.

All of the observation included provides information on the monetary value of ecosystem services, forest area in hectares or transferable units, and the relevant population size. If the forest valuation was estimated at a country level then the information on the country's population of the research conducted year can be found in the World Bank database (Worldbank, 2017). Most of the literature do not give longitude and latitude of the site location, however, if given the site name or location such information can be found in Google maps. This gives a rough estimation for a larger scale of study but sufficient to classify forest by latitude. Benefit transfer studies are excluded from this study to minimizing transfer error. The database beyond country level such as a continent, or at a world scale are not included in the study.

Most of the data used in this study are from published journals or report and few are working paper. Majority of the data are from cross-reference of existing meta-analysis research on forest valuation. This also ensures that the majority of the data are combinable. The total of 121 observations or about forty percent of total observations is in the ESVD or TEEB valuation database. TEEB valuation database has in total 1310 data-points from 290 locations and 267 references. The Ecosystem Services Valuation Database (ESVD) was created by Van der Ploeg and De Groot (2010), which available in excel format from TEEB website. Of these 1310 observations, only 582 observations were included in the study 'global estimates of monetary values of ecosystem services' (De Groot et al., 2012). This shows that data selection is important, to an extent that the authors only uses half of the observation for their estimates.

Though some adjustment has been made from the TEEB database, ESVD assumes that if the author did not specify the year of the research, TEEB uses the publication year as the base. However, for more accuracy of the data especially for journal articles, this is unlikely to be the case as most publication takes at least one year for the material to be reviewed and published, as well as the process of gathering data especially primary and time to analyze those data would take at least a year. Not to mention the process of improving survey design that going back and forth. Therefore, in this study, the proposed two years minus the publication is suggested in the case for journal data that the author did not specify the research year. As for the technical report, working papers, or conference proceedings, the year of validation is assumed to be the same as published year or if stated otherwise. This is based on the assumption that the paper that passes a peer-reviewed process takes longer time.

Follows suggestions from TEEB (2013) guidelines for selecting criteria and based on the objective of the study. In summary, the criteria for data selection for this study should follow the below guidelines:

1. Refer to the original case study not benefit transfer valuation
2. Provide a monetary value of a given ecosystem service
3. Provide information on the forest area or relevant service area. In case if the scale of research is the whole country in general, can use World Bank's data on forest area in hectares.
4. Provide information on the relevant affected population.
5. Provide information on the methodology used.
6. Provide location on the study case, and the scale of research.
7. Make sure the information are from reliable sources either peer-reviewed literature, official report, working papers, or thesis from universities or research institutes.

In table 4.1 listed all valuation studies in this research before eliminated the outliers, a total of 301 observations from 81 references. The database sources are from journals, reports, books, proceedings, working papers, and thesis.

Table 4.1 List of Valuation Studies

Author(s), Year published	Publication Types	Observations
(Adams, Alig, McCarl, Callaway, & Winnett, 1999)	Journal	1
(Adekunle & Agbaja, 2012)	Journal	1
(Anielski & Wilson, 2005)	Report	6
(Arntzen, 1998)	Report	1
(Asquith et al., 2008)	Journal	2
(Bann, 1999)	Report	1
(Barbier, 2007)	Journal	2
(Barnes, 2002)	Book	2
(Beal, 1995)	Journal	2
(Beaumont, Austen, Mangi, & Townsend, 2008)	Journal	1
(Bernard, De Groot, & Campos, 2009)	Journal	7
(Blackwell, 2006)	Proceedings	7
(Borzykowski, Baranzini, & Maradan, 2017)	Report	7
(Boscolo & Buongiorno, 1997)	Journal	15
(Boscolo, Buongiorno, & Panayotou, 1997)	Journal	1
(Boxall, Englin, & Watson, 1999)	Report	4
(Brey et al., 2007)	Journal	5
(Brown & Henry, 1993)	Book	1
(Burbridge & Koesoebiono, 1984)	Book	1
(Bush, Hanley, Moro, & Rondeau, 2015)	Proceedings	2
(Bystrom, 2000)	Journal	1
(Chase et al., 1998)	Journal	6
(Chomitz, Brenes, & Constantino, 1999)	Journal	2
(Chomitz & Kumari, 1995)	Report	2
(Christensen, 1982)	Report	4
(Cooper, Burke, & Bood, 2009)	Report	3
(Corbera et al., 2006)	Working papers	5
(Costanza et al., 1997)	Journal	1
(Cruz, Francisco, & Conway, 1988)	Journal	1

Author(s), Year published	Publication Types	Observations
(Day, 1999)	Working paper	4
(J. A. Dixon & Hodgson, 1988)	Journal	1
(J. A. Dixon, Scura, Carpenter, & Sherman, 1995)	Book	4
(R. K. Dixon, Winjum, Andrasko, J.J., & Schroeder, 1994)	Journal	14
(Dubgaard, 1998)	Book	1
(Dugan, 1990)	Report	1
(Dutschke, 2000)	Book	2
(Emerton & Bos, 2004)	Report	1
(Emerton & Muramira, 1999)	Report	5
(Fleischer & Tsur, 2004)	Discussion Paper	3
(Godoy, Lubowski, & Markandya, 1993)	Journal	7
(Gürlük, 2006)	Journal	1
(Johnson & Baltodano, 2004)	Journal	1
(Kniivila, Ovaskainen, & Saastamoinen, 2002)	Journal	1
(Kosoy, Martinez-Tuna, Muradian, & Martinez-Alier, 2007)	Journal	6
(Kruitilla, 1991)	Book	3
(Kumari, 1996)	Journal	11
(Lal, 1990)	Occasional Papers	1
(Lant & Roberts, 1990)	Journal	2
(Lee & Chun, 1999)	Journal	3
(Levine & Mindedal, 1998)	Thesis	1
(Loomis & Ekstrand, 1998)	Journal	1
(Martínez et al., 2009)	Journal	1
(Mercer, Ramer, & Sharma, 1995)	Journal	2
(The Ministry of Agriculture Nature and Food Quality, 2006)	Report	1
(Mohd-Shahwahid & McNally, 2011)	Report	3
(Naidoo & Adamowicz, 2005)	Journal	1
(Nickerson, 1999)	Journal	1
(Niskanen, 1998)	Journal	3

Author(s), Year published	Publication Types	Observations
(Otrachshenko, 2014)	Report	27
(Ovaskainen, Jarmo, & Pouta, 1998)	Report	7
(Pagiola et al., 2004)	Working Paper	1
(Pagiola, 2008)	Journal	14
(Pattanayak & Kramer, 2001)	Journal	10
(Phillips, 1998)	Report	4
(Pimental et al., 1995)	Journal	3
(Postel & Carpenter, 1997)	Book	1
(Postel & Thompson, 2005)	Journal	3
(Predo, 2003)	Report	4
(Reyes et al., 2001)	Report	5
(Rollins, 1997)	Journal	9
(Romano, Scarpa, Spalatro, & Vigno, 1998)	Proceedings	1
(Rosales et al., 2005)	Report	8
(Ruitenbeek, 1988)	Report	1
(Seenprachawong, 2002)	Report	3
(Shultz, Pinazzo, & Cifuentes, 1998)	Journal	1
(Siikamäki & Layton, 2007)	Journal	1
(Turner et al., 2003)	Journal	4
(Turpie, 2003)	Journal	4
(Tyrtyshny, 2005)	Proceedings	1
(Tyrväinen & Väänänen, 1998)	Journal	6
(Verma, 2001)	Working paper	3
Total		**301**

The journal source represents over half of all the studies, followed by reports and books as shown in figures 4.1 and 4.2. The reports are from respectable sources and institutes such as Food and Agriculture Organization (FAO), International Union for Conservation of Nature (IUCN), Economy and Environment Program for Southeast Asia (EEPSEA), World Resources Institute (WRI), World Bank, Canadian Forest Service, Universiti Putra Malaysia, Fondazione Eni Enrico Matteri (FEEM) which is international research center based in Italy, International Institute for Environment and Development (IIED), and European Tropical Forest Research Network (ETFRN).

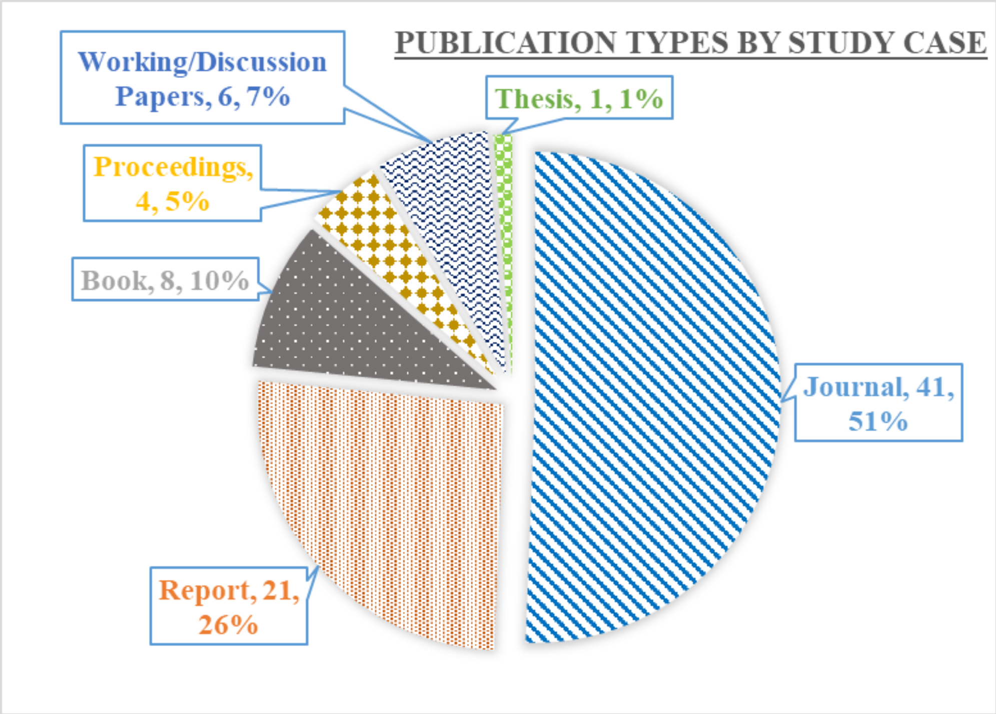

Figure 4.1 Publication Types by Number of Study Case

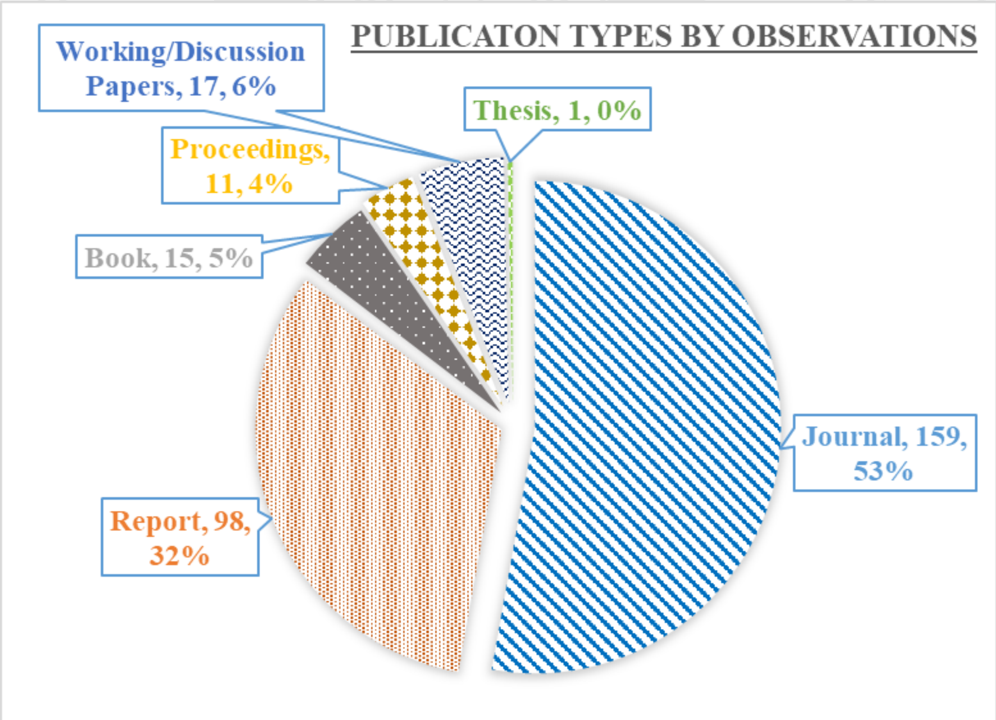

Figure 4.2 Publication Types by Number of Observations

Based on only the journal source, 147 observations out of a total of 159 observations can be found in Scimago Journal & Country Ranking. This represents roughly 92 percent of all journal source, and about half of all observations in the study cases. The Scimago Journal and Country Rank (SJR) provides a scientific indicator of the information contained in the Scopus database. Scopus is a database from Elsevier. SJR measures the number of citations received by a journal. SJR numeric value indicated the average number of weighted citation received during a selected year per document published in that journal during the previous three years (Scimago, 2018). Illustrated in the table 4.2 is the journal ranking information from SJR in 2018, which shows the weighted citation from 2016-2018. The higher SJR values indicate a higher impact factor or more prestige the journal. Similarly, h-index or Hirsch index is an author-level metric that measures both the productivity and citation impact of the publications. Also follows to same rules as SJR the higher the h-index number the more scholarly impact the journals.

Table 4.2 Journal Ranking

Journal	**SJR**	**H-index**	**Obs.**
Ambio	1.69	108	11
Canadian journal of Agricultural Economics	0.44	31	9
Climatic Change	1.62	162	14
Commonwealth Forest Review	0.57	41	15
Ecological Economics	1.77	174	41
Economic Botany	0.52	61	7
Economic Policy	4.17	67	2
Environment and Development Economics	0.77	54	3
Environment and Planning A	1.55	112	2
Environmental and Resource Economics	1.11	81	1
Forest Ecology and Management	1.43	152	1
Forest Policy and Economics	1.33	60	1
Journal of Environmental Economics and Management	2.23	105	1

Journal	SJR	H-index	Obs.
Journal of Environmental Management	1.21	146	3
Journal of Forest Economics	0.76	31	3
Land economics	1.21	77	7
Landscape and Urban Planning	1.83	132	6
Marine Pollution Bulletin	1.22	147	1
Natural Resource Forum	0.55	43	3
Nature	16.35	1096	1
Science	13.25	1058	3
The Science of the Total Environment	1.54	205	2
Water Resources Research	2.14	183	10
Total			147

*Note: SJR as of the year 2018

Based on 147 journal observations, minimum SJR ranking is 0.44, maximum is 16.35, and average SJR ranking is 1.76. The H-Index is between 31 and 1096, and the average ranking is 145.72. A large portion of the database is from the Journal of Ecological Economics with 41 observations, which has SJR ranking of 1.767 and H-Index of 174. The Journal that has high SJR and H-Index are Nature and Science journal, both are multidisciplinary. The citations, in general, behave differently across different fields. Therefore, these rankings should be used only when comparing the publication of the same discipline.

4.1.2 Data Coding and Standardization

The data extracted from each study were first coded into a Microsoft Excel spreadsheet, then export it to Stata program to run the regression analysis. The validation year used in this study is the research conducted year, not publication year. In the case that the study year was not mention in the literature, the published year minus two years was assumed to be the study year. This way the valuation is closer to when the research was conducted, or survey questions.

The original data from different literature are reported in different metrics, currencies, and referring to different years. In order for these data point to be comparable, original values need to be standardized into 2017 international values (PPP adjusted dollars).

Follow TEEB standardized procedures (Van der Ploeg et al., 2010), all the estimates were converted into the official local currency. For the conversion to local currencies the World Bank data series ‘Official exchange rate (LCU per USD)’ was used. In the case the data was not in the local currency, follow the equation below:

$$Value\ (local\ Currency) = \frac{Value\ (Other\ Currency)}{OER\ (Other\ Currency)}\ x\ OER\ (local\ currency) \quad (1)$$

Once the valuation in the local currency, adjust to 2017 values in local currencies by using GDP deflator from of the study year and GDP deflator in the year 2017 using data from World Bank Indicator (2017)

$$Value\ (in\ 2017) = \frac{Value\ (study\ year) x\ GDP\ deflator\ (2017)}{GDP\ deflator\ (study\ Year)} \quad (2)$$

Then, the currency is converted to international dollars using the purchasing power parity (PPP) conversion factor from the World Bank (2017):

$$Value\ (international\ \$) = \frac{Value\ (local\ currency)}{PPP\ (year\ 2017)} \quad (3)$$

When dealing with international transfer, the values are standardized using only exchange rates and deflation rates. There are still many underlying values not interpreted. As Groot et al. (2012) have pointed out that by standardizing values using GDP deflators and PPP conversion factors still not cover the changes in population, changes in the scarcity of nature, marginal values of climate change mitigation which all leads to higher demand of ecosystem services. Therefore, the standardized values of ecosystem services are likely to be underestimated.

Once the values are normalized into international USD, the next step is to standardized into per hectare per year unit. Since the study from all over the world is included, the variance of monetary value per hectare is high. The range is between 0.0002 and 4,132,075 (international dollars) per hectare per year in 2017, and the standard deviation is 308,941. The mean forest values per hectare per year is 41,404 international dollars. This high variation is to be expected as from 1310 data points in Ecosystem Services Valuation Database (ESVD), the variation is also high. In ESVD the range of forest value after standardized is between 0.00004848 and 38,249,593 (international dollars) per hectare per year in 2007. The average ESVD is 508,156 (international dollars) per hectare per year in 2007 and the standard deviation is 11,431,309. (Van der Ploeg & De Groot, 2010)

In this research, the forest value per hectare per person was adjusted to try to solve this problem. The purpose of finding per person unit as well so that the estimated value can be easily applied and adjust to different size, population, and policy implementation. The value of land in one country is not comparable to the same hectare in another. The countries that have a vast majority of land and low population density value land and ecosystem differently than high population density. Some of the weakness of using a per hectare as a unit of valuation as pointed out by (Van der Ploeg et al., 2010) is that given a value per hectare unit gives the impression that each hectare in an ecosystem is equally productive, which is not the case for most services.

The international dollars values per hectare per year divided by the relevant population to get a generalized value per hectare per person in 2017. The result then multiplied by 1000 for simpler numbers. Non-use valuation and water usage are commonly involved in local representation. Mos of watershed study estimates the local usage both upstream and downstream. From 301 observations the minimum number for international dollars per hectare per 1000 person is still very low at 5.11e-10, and a maximum of 86085, an average value of 768, and the standard deviation is 6436. From the literature review, Smith and Pattanayak (2002) suggested that it is better to drop the values that do not fit the standard to improve the overall quality of the model. These values are called 'outliers', 13 observations were dropped concluding 288 observations used in this meta-regression. From 288 observations, the minimum values remain 5.11e-10, the maximum value is 275 international dollars, the average value is 8.95 international dollars, and the standard deviation dropped to 35.32. The outliers are 13 observations from 2 study cases. Both study cases are from Finland and the scale of study was local and plot.

Table 4.3 summarize the list of dependent variables and explanatory variables. The forest ecosystem values are normalized to PPP adjusted dollars per hectare per 1000 persons per year in 2017. Ecosystem services and biomes variables are based on classification defined by TEEB. Recalled the definition of forest classification in chapter 3, forest by latitude can be classify into tropical, temperate, and boreal. In this study forest by latitude for the tropical forest defined by studies that has study site located between the equator to 34°north and 34°south; temperate forest between 35° and 55° north and south; and the boreal forest is the area above and below 55 °. The variable list identifies two class of methodology one is generalized and one in more details, which use later on in different regression models. Variables 'population', 'forest area', 'socioeconomics', and 'regional' are based on the world bank database.

Table 4.3 List of Variables

VARIABLES	**CODE**	**DETAILS**	**TYPES OF VLBS**
Dependent Variable	Y	Ecosystem Values in international US per 1000 person per year (2017)	Dependent
Ecosystem Services	ES_PROV	Provisioning (=1, 0 otherwise)	Dummy
	ES_REGU	Regulating (=1, 0 otherwise)	Dummy
	ES_HABT	Habitat (=1, 0 otherwise)	Dummy
	ES_CULT	Cultural (=1, 0 otherwise)	Dummy
	ES_OTHERS	Additional, General and Various (=1, 0 otherwise)	Dummy
Use Values	USE	Use values (=1, 0 otherwise)	Dummy
	NONUSE	Non-use Values (=1, 0 otherwise)	Dummy

VARIABLES	CODE	DETAILS	TYPES OF VLBS
Forest Types by Latitude	TROP	Tropical (=1, 0 otherwise)	Dummy
	TEMP	Temperate (=1, 0 otherwise)	Dummy
	BOREAL	Boreal (=1, 0 otherwise)	Dummy
Forest Types by Biome	TEMPB	Forests [Temperate and Boreal] (=1, 0 otherwise)	Dummy
	TROPI	Tropical Forest (=1, 0 otherwise)	Dummy
	WETLC	Coastal wetlands (=1, 0 otherwise)	Dummy
	WETLI	Inland Wetlands (=1, 0 otherwise)	Dummy
	WOODL	Woodlands (=1, 0 otherwise)	Dummy
	GRASS	Grasslands (=1, 0 otherwise)	Dummy
	CULTU	Cultivated (=1, 0 otherwise)	Dummy
	MULTIES	Multiple Ecosystems (=1, 0 otherwise)	Dummy
Methodology	CVM	Contingent Valuation Method (=1, 0 otherwise)	Dummy
	TCM	Travel Cost Method (=1, 0 otherwise)	Dummy
	MKT	Market Value (=1, 0 otherwise)	Dummy
Methodology (in details)	CVGV	Contingent Valuation (CV) and Group Valuation (GV) (=1, 0 otherwise)	Dummy
	CC	Contingent Choice (=1, 0 otherwise)	Dummy
	TC	Travel Cost (=1, 0 otherwise)	Dummy
	DM	Direct market pricing (=1, 0 otherwise)	Dummy
	FI	Factor Income / Production Function (=1, 0 otherwise)	Dummy
	AC	Avoided Cost (=1, 0 otherwise)	Dummy
	RC	Replacement Cost (=1, 0 otherwise)	Dummy
	MR	Mitigation and Restoration Cost (=1, 0 otherwise)	Dummy

VARIABLES	CODE	DETAILS	TYPES OF VLBS
	PES	Payment of Ecosystem Services (=1, 0 otherwise)	Dummy
	TEV_OTH	Total Economic Value (TEV) and Other Methods (=1, 0 otherwise)	Dummy
Population	LNPOPD	LN of Population Density (people per sq. km of land area)	Continuous
Forest Area	LNAREAP	LN Forest Area (% of land)	Continuous
Socioeconomic	LNGDPCAP	Ln GDP per capita	Continuous
Regional	NAC	North America (=1, 0 otherwise)	Dummy
	LCN	Latin America & Caribbean (=1, 0 otherwise)	Dummy
	ECS	Europe & Central Asia (=1, 0 otherwise)	Dummy
	EAS	East Asia & Pacific (=1, 0 otherwise)	Dummy
	SAS	South Asia (=1, 0 otherwise)	Dummy
	SSF	Sub-Saharan Africa (=1, 0 otherwise)	Dummy
	MEA	The Middle East & North Africa (=1, 0 otherwise)	Dummy
Scale of Studies	SCALE	Scales of studies (1=Plot, 2=Local, 3=City, 4=Landscape; 5=Province; and 6= Country)	Dummy
Protected Status	P_FP	Forest Fully Protected (=1, 0 otherwise)	Dummy
	P_PP	Forest Partially Protected (=1, 0 otherwise)	Dummy
	P_NP	Not Protected (=1, 0 otherwise)	Dummy
	P_NA	Protected Status Unknown (=1, 0 otherwise)	Dummy
Year	YR	Study Conducted Year (1990=1, 1992 = 2, … , 2014 = 25)	Continuous

4.1.3 Data Summary

Table 4.4 Descriptive Analysis of Continuous Variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Y	288	8.95	35.32	0.00	275.02
AREAP	288	39.73	20.46	0.07	82.11
LNAREAP	288	3.46	0.86	-2.66	4.41
POPD	288	118.17	115.33	3.14	587.16
LNPOPD	288	4.19	1.31	1.14	6.38
GDPCAP	288	17938.35	19999.22	448.40	80333.45
LNGDPCAP	288	9.14	1.26	6.11	11.29

Table 4.5 Descriptive Analysis of Count Variables

Variable	Count	Mean	Std. Dev.	Min	Max
ES_PROV	83	0.2882	0.4537	0	1
ES_REGU	69	0.0868	0.2820	0	1
ES_HABT	25	0.2396	0.4276	0	1
ES_CULT	98	0.3403	0.4746	0	1
ES_OTHERS	13	0.0451	0.2080	0	1
USE	256	0.8889	0.3148	0	1
NONUSE	32	0.1111	0.3148	0	1
TROP	301	0.6979	0.4600	0	1
TEMP	78	0.2708	0.4452	0	1
BOREAL	9	0.0313	0.1743	0	1
TEMPB	71	0.2465	0.4317	0	1
TROPI	140	0.4861	0.5007	0	1
WETLC	22	0.0764	0.2661	0	1
WETLI	22	0.0764	0.2661	0	1
WOODL	2	0.0069	0.0832	0	1
GRASS	18	0.0625	0.2425	0	1
CULTU	9	0.0313	0.1743	0	1

Variable	Count	Mean	Std. Dev.	Min	Max
MULTIES	4	0.0139	0.1172	0	1
CVM	94	0.3264	0.4697	0	1
TCM	24	0.0833	0.2769	0	1
MKT	170	0.5903	0.4926	0	1
CVGV	88	0.3056	0.4614	0	1
CC	6	0.0208	0.1431	0	1
TC	24	0.0833	0.2769	0	1
DM	63	0.2188	0.4141	0	1
FI	9	0.0313	0.1743	0	1
AC	14	0.0486	0.2154	0	1
RC	12	0.0417	0.2002	0	1
MR	28	0.0313	0.1743	0	1
PES	34	0.0972	0.2968	0	1
TEV_OTH	9	0.1181	0.3232	0	1
NAC	31	0.1076	0.3105	0	1
TLA	72	0.2500	0.4338	0	1
ECA	43	0.1493	0.3570	0	1
EAS	89	0.3090	0.4629	0	1
SAS	9	0.0313	0.1743	0	1
SSA	34	0.1181	0.3232	0	1
MEA	10	0.0347	0.1834	0	1
SCALE	288	4.5556	1.8204	1	6
P_FP	58	0.2014	0.4017	0	1
P_PP	184	0.6389	0.4812	0	1
P_NP	4	0.0139	0.1172	0	1
P_NA	42	0.1458	0.3536	0	1
YR	288	10.5417	5.3970	1	25

The average year in this data base is between 1999 and 2000. Earliest observations are from a case study conducted in 1990, and the most recent study included was conducted in 2014.

The proportion of ecosystem services is shown in figure 4.3. The variable 'ES_OTHERS' is from a combination of 'Additional and General Services' 9 observations and 'Various Services' 4 observations.

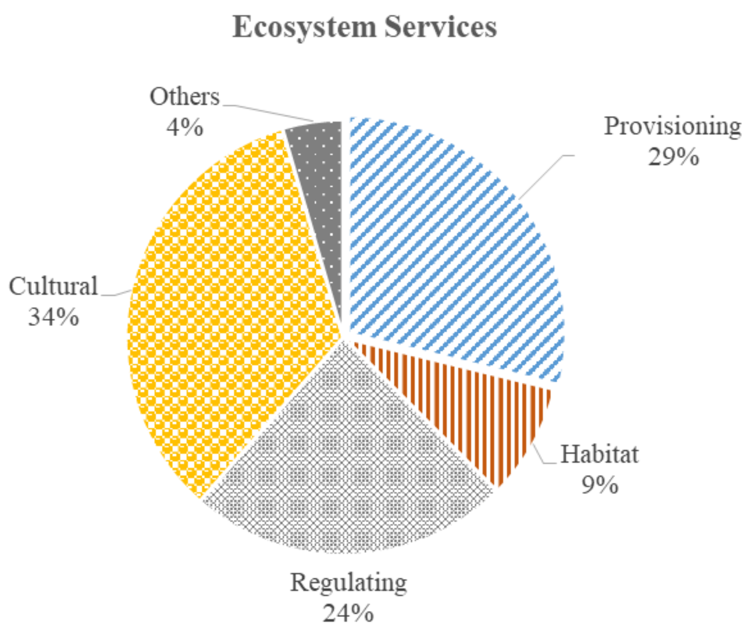

Figure 4.3 Ecosystem Services (%)

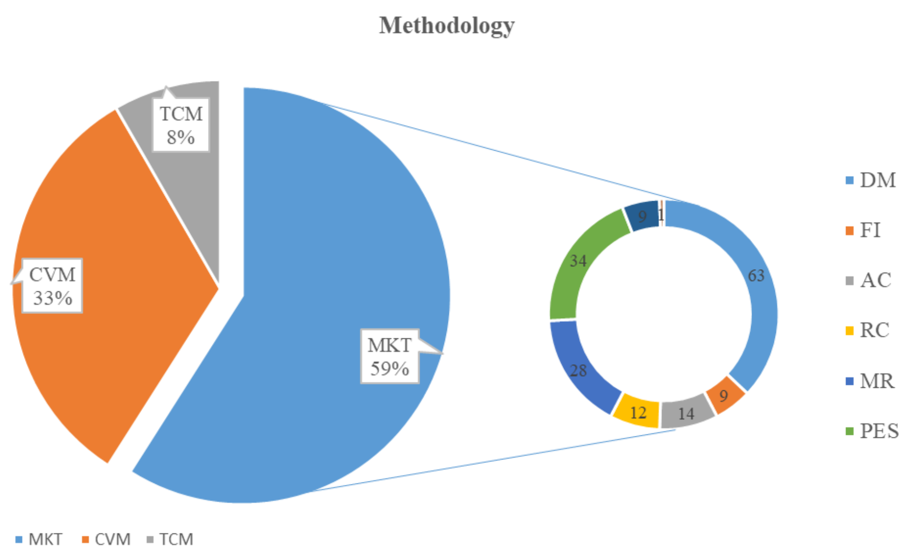

Figure 4.4 Methodology (%)

Table 4.6 List of Valuation Methodologies

Variables	Methodology	Obs.	Mean Y
CVM	Contingent Valuation (CV)	87	3.02
	Group Valuation (GV)	1	1.54
	Contingent Choice (CC)	6	22.46
TCM	Travel Cost (TC)	24	5.03
MKT	Direct market pricing (DM)	63	2.39
	Factor Income / Production Function (FI)	9	4.55
	Avoided Cost (AC)	14	1.45
	Replacement Cost (RC)	12	32.08
	Mitigation and Restoration Cost (MR)	28	39.04
	Payment of Ecosystem Services (PES)	34	10.71
	Total Economic Value (TEV)	9	0.44
	Others (OTH)	1	0.01
Total		**288**	

For a large portion of the research is represented by the market value of environmental valuation. The market valuation can further be categorized in direct market pricing, factor income/ production function, avoided cost, replacement cost, mitigation and restoration cost, PES, and others. The methodology portion breakdown is represented in figure 4.4. The ecosystem values derived from benefit transfer are not included in this meta-analysis to avoid compounding transfer errors. Only original case studies are included in this research.

The detail description of the biome and ecosystem used in this study are shown in Table 4.7. The detailed ecosystem is not included in the regression as there are too few observations in many of the categories that it will not represent that ecosystem. These descriptions are according to TEEB database (Van der Ploeg & De Groot, 2010). Figures 4.5 show ecosystem services by each regional, and figures 4.6 shows ecosystem services and biome studies used in this meta-analysis.

Table 4.7 List of Observations by Biomes and Ecosystem

Biomes	**Ecosystem**	**Obs.**
Forests [Temperate and Boreal]	Boreal / coniferous Forests	6
Forests [Temperate and Boreal]	Forest [unspecified]	5
Forests [Temperate and Boreal]	hill Evergreen forest	2
Forests [Temperate and Boreal]	Mixed Deciduous forest	29
Forests [Temperate and Boreal]	Pine forest or Coniferous Forest	24
Forests [Temperate and Boreal]	Temperate forest general	5
Tropical Forest	Tropical Rainforest	78
Tropical Forest	Tropical forest general	40
Tropical Forest	Tropical Cloud forest	6
Tropical Forest	Dipterocarp	16
Coastal wetlands	Mangroves	18
Coastal wetlands	Open water [general]	2
Coastal wetlands	Tidal Marsh	2
Inland Wetlands	Floodplains	2
Inland Wetlands	Lakes	3
Inland Wetlands	Peat wetlands	1
Inland Wetlands	Swamps / marshes	12
Inland Wetlands	Wetlands [unspecified]	4
Woodlands	Mediterranean woodlands	1
Woodlands	Other woodlands	1
Grasslands	Savannah	12
Grasslands	Pastures tropical	1
Grasslands	Temperate natural grasslands	1
Grasslands	Grasslands [unspecified]	3
Grasslands	Other grasslands	1
Cultivated	Agro-forestry [cultivated]	1
Cultivated	Aquaculture	2
Cultivated	Croplands	6
Multiple Ecosystems	Multiple ecosystems	4
Total		288

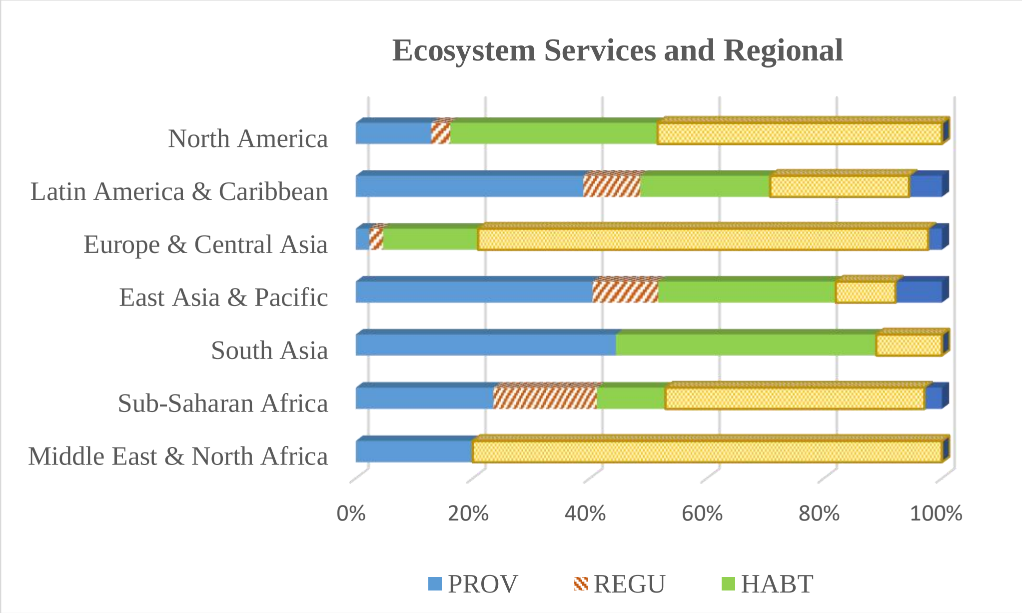

Figure 4.5 Ecosystem and Regional Studies

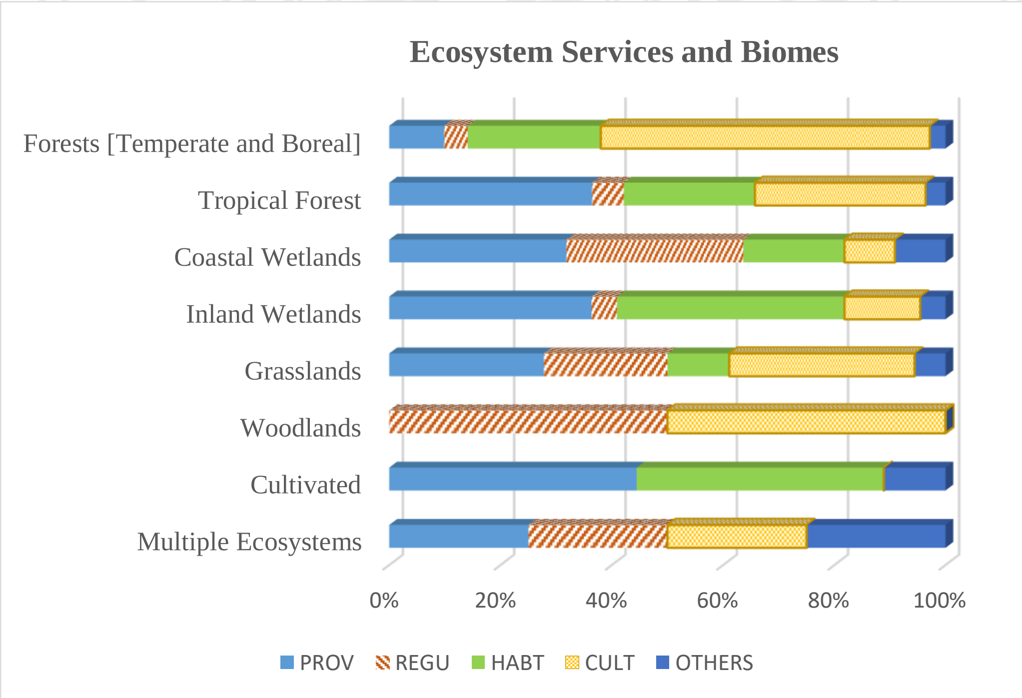

Figure 4.6 Ecosystem and Biomes Studies

The scale of study is hypothesized to have some significant influence on forest value as the values of small scale study may not have high monetary value per hectare as a large level scale. However, the small scale forest directly impacts the nearby community. People are likely to value the ecosystem services higher when the impact is prominent and foreseeable. Therefore when looking forest values per individual smaller scale studies may reflect higher consumer surplus. The list of the scales of research and the observations used is summarized in table 4.8.

Table 4.8 List of Observations by Scale of Study

Scale	**Descriptions**	**Obs.**
Plot	Very small study area, part of the ecosystem.	16
Local	The case study at ecosystem level. (a forest/coral reef/ wetland level)	64
Municipality / City	Study at the level of a municipality. Including several ecosystems.	1
Landscape / District / Water basin	Study at landscape level Including several municipalities, multiple ecosystems.	21
Province / Region	Study at the level of a province or region of a country.	35
Country	Study at the country level.	151
Total		288

The values attributed to ecosystem services depend on social, cultural and economic context, and will differ between people and over time (McVittie & Hussain, 2013), therefore, the range of database is set to the study valuation from the year 1990 onwards. Ideally, the more recent the publication represents a more precise and updated valuation of people preference but this also has to be offset with the number of information available and can be gathered within specific range.

4.2 Methodology

The regression model adopted in this study is simple Ordinary Least Square (OLS) model. The list of dependent variables and explanatory variables refers to table 4.3. The values are normalized to international US dollars per hectare per year per relevant population and adjusted inflation rate to the year 2017 values.

Recalls, the benefit transfer function (Rosenberger & Loomis, 2003):

$$V_{Pj} = f_s(Q_{S|P_j}, \bar{X}_{S|P_j}, M_{S|P_j})$$

The value of the policy site (V_{Pj}), is equals to Y_i the forest value in international dollars terms in 2017 per hectare per 1000 person.

A function of quantity or quality variables (Q) includes variables of Ecosystem Services, Scale of study.

A function of socio-demographic variables (X) includes site characteristics such as Forest types, Forest Area, Geographical location (Regional), demographic description (Population Density), and socioeconomic variable (GDP per Capita).

A function of methodological variables (M) includes the methodology used which are CVM, TCM, and MKT variables.

The above benefit transfer function is applied to regress Ordinary Least Square (OLS) model, the double log functions of meta-analysis forest valuation are as follows:

4.3 Double-log Regression Models

4.3.1 OLS Regression Model 1

The formula for model 1 written:

$$lnY_i = \alpha + \beta_1 Forest\ by\ latitude + \beta_2 Methodology + \beta_3 LnPopulation + \beta_4\ LnForest\ Area + \beta_5 LnSocioeconomics$$

Where Y is the dependent variable with i observation, α is a constant number and β is the coefficient of the regression.

Table 4.9 OLS Regression Model 1

Lny	**Coef.**	**Std. Err**	**t**	**P>t**	**P>t [95% Conf. Interval]**	
CONSTANT	-0.37	2.43	-0.15	0.88	-5.15	4.42
BOREAL	-7.07	1.36	-5.20	***0.00	-9.74	-4.39
TEMP	-1.39	0.70	-1.98	**0.05	-2.77	0.00
CVGV	-2.37	0.81	-2.92	***0.00	-3.96	-0.77
CC	-2.09	1.62	-1.29	0.20	-5.27	1.10
DM	-4.02	0.89	-4.50	***0.00	-5.77	-2.26
AC	-2.52	1.19	-2.12	**0.04	-4.86	-0.17
RC	-0.80	1.24	-0.64	0.52	-3.24	1.65
MR	-4.05	0.99	-4.08	***0.00	-6.00	-2.09
FI	-2.30	1.42	-1.62	0.11	-5.08	0.49
PES	-1.34	1.00	-1.35	0.18	-3.30	0.62
M_OTH	-2.37	1.38	-1.72	*0.09	-5.09	0.34
LNPOPD	-0.31	0.19	-1.64	0.10	-0.68	0.06
LNAREAP	0.89	0.26	3.34	***0.00	0.36	1.41
LNGDPCAP	-0.09	0.24	-0.35	0.72	-0.57	0.40
No. of observations						**288**
F(14,273)						**6.11**
R-Squared						**0.2385**
Adj. R-Squared						**0.1995**

Note: * p<0.10, 90% statistically significant
** p<0.05, 95% statistically significant
***p<0.01, 99% statistically significant

In the first model, the dummy variable TROP is drop out of forest by latitude, as well as travel cost method is drop out of methodology. The result shows that forest by latitude both BOREAL and TEMP are positive and statistically significant at 99% and 95% level consecutively. When run the regression separately, tropical forest by latitude is highly significant with positive coefficient. Methodology variables also have some influence on forest values with contingent and group valuation; direct market pricing; and mitigation and restoration cost methodologies are 99% statistically significant while avoided cost methodology is 95% statistically significant. Methodologies listed in the regression all have negative coefficient, which means that from the observations in this study travel cost method has high positive correlation to forest values. Forest area variable is also positively correlate to forest values and is 99% statistically significant.

4.3.2 OLS Regression Model 2

The formula for model 2 written:

$$lnY_i = \alpha + \beta_1 Forest\ by\ latitude + \beta_2 Forest\ by\ Biome + \beta_3 Methodology + \beta_4 LnPopulation + \beta_5 LnForest\ Area + \beta_6 LnSocioeconomics$$

, where Y is the dependent variable with i observation, α is a constant number and β is the coefficient of the regression.

Table 4.10 OLS Regression Model 2

Lny	**Coef.**	**Std.Err**	**t**	**P>t**	**P>t [95% Conf. Interval]**	
CONSTANT	-5.76	2.39	-2.41	**0.02	-10.47	-1.06
BOREAL	-6.08	1.47	-4.15	***0.00	-8.97	-3.20
TEMP	-0.42	0.80	-0.52	0.60	-2.01	1.16
TEMPB	-0.79	1.07	-0.74	0.46	-2.89	1.32
TROPI	1.55	0.93	1.65	*0.10	-0.30	3.39
WETLC	1.06	1.16	0.91	0.36	-1.23	3.35
WETLI	0.51	1.15	0.44	0.66	-1.76	2.78
WOODL	-0.83	2.66	-0.31	0.76	-6.07	4.42
CULTV	0.75	1.51	0.49	0.62	-2.23	3.72
MULTIES	3.07	1.97	1.55	0.12	-0.82	6.95
CVM	0.65	0.53	1.23	0.22	-0.39	1.68
TCM	3.42	0.85	4.04	***0.00	1.75	5.08
LNPOPD	-0.36	0.18	-2.02	**0.04	-0.72	-0.01
LNAREAP	0.83	0.28	2.99	***0.00	0.28	1.37
LNGDPCAP	0.11	0.25	0.45	0.65	-0.37	0.60
No. of observations						**288**
F(14,273)						**5.39**
R-Squared						**0.2167**
Adj. R-Squared						**0.1765**

Note: * p<0.10, 90% statistically significant
** p<0.05, 95% statistically significant
***p<0.01, 99% statistically significant

The second model is design to test forest biome whether biome characteristic have influence on forest values. In the forest by latitude, TROP is drop out of the equation, BOREAL reports to be 99% statistically significant. The dummy variable GRASS is dropped out of this model. The relationship between forest biome and forest values is inconclusive. The variable TROPI found a positive coefficient on forest values at a 90% statistically significant level. For other biomes, the correlations are not statistically significant.

4.3.3 OLS Regression Model 3

The formula for model 3 written:

$$lnY_i = \alpha + \beta_1 Forest\ by\ latitude + \beta_2 Methodology + \beta_3 LnPopulation + \beta_4\ LnForest\ Area + \beta_5 LnSocioeconomics + \beta_6 Scale\ of\ studies$$

, where Y is the dependent variable with i observation, α is a constant number and β is the coefficient of the regression.

Table 4.11 OLS Regression Model 3

Lny	Coef.	Std.Err	t	P>t	P>t [95% Conf. Interval]	
CONSTANT	3.28	2.18	1.51	0.13	-1.00	7.57
BOREAL	-5.48	1.17	-4.70	***0.00	-7.78	-3.19
TEMP	-0.30	0.60	-0.50	0.62	-1.49	0.88
CVM	-0.14	0.43	-0.32	0.75	-0.99	0.71
TCM	2.17	0.70	3.09	***0.00	0.79	3.56
LNPOPD	-0.26	0.15	-1.69	*0.09	-0.56	0.04
LNAREAP	0.15	0.23	0.63	0.53	-0.32	0.61
LNGDPCAP	1.90e-03	0.21	0.01	0.99	-0.41	0.41
SCALE	-1.12	0.11	-10.22	***0.00	-1.33	-0.90
No. of observations						**288**
F(8,279)						**23.65**
R-Squared						**0.4041**
Adj. R-Squared						**0.3870**

Note: * p<0.10, 90% statistically significant
** p<0.05, 95% statistically significant
***p<0.01, 99% statistically significant

In the third model, the scale of studies is tested with 99% statistically significant and negatively correlate. This means larger study scale would give smaller valuation. This is due to the bigger the scale of study has also larger divided population, and diminishing returns. In the forest by latitude, TROP is drop out of the equation, BOREAL reports to be 99% statistically significant. Methodology variable TCM is also positively correlated and 99% statistically significant.

4.3.4 OLS Regression Model 4

The formula for model 4 written:

$$lnY_i = \alpha + \beta_1 Ecosystem\ Services + \beta_2 Use + \beta_3 Forest\ by\ latitude + \beta_4 Methodology + 5 LnPopulation + \beta_6\ LnForest\ Area + \beta_7 LnSocioeconomics + \beta_8 Regional + \beta_9 Scale\ of\ studies$$

, where Y is the dependent variable with i observation, α is a constant number and β is the coefficient of the regression.

Table 4.12 OLS Regression Model 4

Lny	**Coef.**	**Std.Err**	**t**	**P>t**	**P>t [95% Conf. Interval]**	
CONSTANT	9.81	2.93	3.35	***0.00	4.05	15.58
ES_PROV	-2.01	0.69	-2.91	***0.00	-3.36	-0.65
ES_HABT	-2.15	0.81	-2.65	***0.01	-3.75	-0.55
ES_REGU	-0.87	0.90	-0.97	0.33	-2.65	0.90
ES_OTHERS	0.65	1.70	0.38	0.70	-2.70	4.01
USE	-0.58	0.94	-0.62	0.53	-2.43	1.26
BOREAL	-2.84	1.38	-2.06	**0.04	-5.56	-0.13
TEMP	1.33	0.86	1.53	0.13	-0.38	3.03
CVGV	-2.46	0.80	-3.08	***0.00	-4.03	-0.89
CC	-2.65	1.43	-1.86	*0.07	-5.47	0.16
DM	-1.24	0.97	-1.28	0.20	-3.14	0.67
AC	-0.76	1.27	-0.60	0.55	-3.27	1.75
RC	-0.15	1.41	-0.11	0.92	-2.94	2.64
MR	-3.44	1.23	-2.79	***0.01	-5.87	-1.01
FI	-2.08	1.35	-1.55	0.12	-4.73	0.57
PES	-1.76	1.23	-1.42	0.16	-4.19	0.67
TEV_OTH	-2.22	1.94	-1.14	0.26	-6.05	1.61
LNPOPD	-0.49	0.19	-2.62	***0.01	-0.86	-0.12
LNAREAP	0.55	0.31	1.77	*0.08	-0.06	1.17
LNGDPCAP	-0.33	0.26	-1.26	0.21	-0.84	0.19
NAC	-3.49	1.07	-3.27	***0.00	-5.59	-1.39
LCN	-0.12	0.62	-0.19	0.85	-1.35	1.11

Lny	**Coef.**	**Std.Err**	**t**	**P>t**	**P>t [95% Conf. Interval]**	
ECS	-1.72	1.04	-1.65	0.10	-3.77	0.33
SAS	-0.05	1.10	-0.04	0.97	-2.21	2.12
SSF	-1.13	0.86	-1.31	0.19	-2.82	0.57
MEA	1.70	1.46	1.17	0.25	-1.17	4.58
SCALE	-1.19	0.13	-9.38	***0.00	-1.44	-0.94
No. of observations						**288**
F(26,261)						**10.62**
R-Squared						**0.5140**
Adj. R-Squared						**0.4656**

Note: * p<0.10, 90% statistically significant
** p<0.05, 95% statistically significant
***p<0.01, 99% statistically significant

In model 4 tested the relationship between dependent variable Y and different types of ecosystem services, methodology, and scale of study. Ecosystem culture service tends to have high values when compares to other services. Three methodologies out of nine are statistically significant which includes contingent valuation, contingent choice, and mitigation and restoration cost. In regional, only North America variable is statistically significant. The scale of study also reported a similar result in model 3 with 99% statistically significant level and negatively correlated.

4.3.1 OLS Regression Model 5

The formula for model 5 written:

$$lnY_i = \alpha + \beta_1 Ecosystem\ Services + \beta_2 Forest\ by\ latitude + \beta_3 Methodology + \beta_4 LnPopulation + \beta_5\ LnForest\ Area + \beta_6 LnSocioeconomics + \beta_7 Protected\ Status + \beta_8 Year$$

, where Y is the dependent variable with i observation, α is a constant number and β is the coefficient of the regression.

Table 4.13 OLS Regression Model 5

Lny	**Coef.**	**Std.Err**	**t**	**P>t**	**P>t [95% Conf. Interval]**	
CONSTANT	3.36	2.36	1.42	0.16	-1.29	8.02
USE	-1.46	0.76	-1.93	*0.05	-2.95	0.03
BOREAL	-5.77	1.13	-5.10	***0.00	-8.00	-3.54
TEMP	-0.42	0.61	-0.70	0.49	-1.62	0.77
CVM	-0.86	0.51	-1.71	*0.09	-1.86	0.13
TCM	1.81	0.72	2.52	**0.01	0.40	3.22
LNPOPD	-0.41	0.16	-2.54	**0.01	-0.73	-0.09
LNAREAP	0.39	0.24	1.66	*0.10	-0.07	0.86
LNGDPCAP	-0.08	0.21	-0.36	0.72	-0.49	0.34
SCALE	-1.17	0.12	-9.91	***0.00	-1.40	-0.93
P_FP	1.60	0.70	2.31	**0.02	0.23	2.97
P_PP	1.31	0.53	2.46	**0.01	0.26	2.36
P_NP	3.06	1.58	1.94	*0.05	-0.05	6.16
YR	0.10	0.04	2.64	***0.01	0.02	0.17
No. of observations						**288**
F(13, 274)						**17.43**
R-Squared						**0.4527**
Adj. R-Squared						**0.4267**

Note: * p<0.10, 90% statistically significant
** p<0.05, 95% statistically significant
***p<0.01, 99% statistically significant

The variable forest protected area was tested in model 5 and found statistically significant in all three protected level. The unknown protected status is dropped out of this equation. The scale of the study shows similar negatively correlates figures. Both methodology CVM and TCM are statistically significant at a 90% and 95% level.

Table 4.14 shows the summary of all coefficient in model 1 to 5. From the regression result, forest by latitude (BOREAL) is found to be statistically significant across all five models. In terms of regional geographical location, only North America is statistically significant in the model. Therefore, forest by latitude might be better representation in terms of indication of forest types and geographical location. Methodologies conducted also has some significant influences on forest values. Population density has a negatively correlate to forest value (Y) as evident in model 2-5. Percentage of the country's forested area is positively correlated to Y in four out of five models.

All five meta-regression models have been checked for multicollinearity using variance inflation factor (VIF). All the models have VIF less than 10, which is an acceptable standard (see appendix C).

Table 4.14 Regression Results

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
CONSTANT	-0.37	**-5.76	3.28	***9.81	3.36
ES_PROV				***-2.01	
ES_REGU				***-2.15	
ES_HABT				-0.87	
ES_OTHERS				0.65	
USE				-0.58	*-1.46
BOREAL	***-7.07	***-6.08	***-5.48	**-2.84	***-5.77
TEMP	**-1.39	-0.42	-0.30	1.33	-0.42
TEMPB		-0.79			
TROPI		*1.55			
WETLC		1.06			

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
WETLI		0.51			
WOODL		-0.83			
CULTU		0.75			
MULTIES		3.07			
CVM		0.65	-0.14		*-0.86
TCM		***3.42	***2.17		**1.81
CVGV	***-2.37			***-2.46	
CC	-2.09			*-2.65	
DM	***-4.02			-1.24	
AC	**-2.52			-0.76	
RC	-0.80			-0.15	
MR	***-4.05			***-3.44	
FI	-2.30			-2.08	
PES	-1.34			-1.76	
M_OTH	*-2.37			-2.22	
LNPOPD	-0.31	**-0.36	*-0.26	***-0.49	**-0.41
LNAREAP	***0.89	***0.83	0.15	*0.55	*0.39
LNGDPCAP	-0.09	0.11	1.90e-03	-0.33	-0.08
NAC				***-3.49	
LCN				-0.12	
ECS				-1.72	
SAS				-0.05	
SSF				-1.13	
MEA				1.70	
SCALE			***-1.12	***-1.19	***-1.17
P_FP					**1.60
P_PP					**1.31
P_NP					*3.06
YR					***0.10
Obs.	**288**	**288**	**288**	**288**	**288**
R-squared	**0.24**	**0.22**	**0.40**	**0.51**	**0.45**
Adj. R-squared	**0.20**	**0.18**	**0.39**	**0.47**	**0.43**

Across all models, the result shown that the methodology used has some influence over ecosystem values especially for Travel Cost Method (TCM). De Groot et al. (2012) results also shown that the valuation methodology can have a significant influence on estimated values. Hence, policymakers can be selective about using the data for their personal benefits. Forest Area has a positive correlation on forest values with four out of five models are statistically significant. The most efficient way to classify forest by geographical location is by latitude. Forest by latitude can be classified in general yielding more accurate results than others. Further detailed classification can be added in the model such as forest biome.

As mention earlier the valuation from stated preference such as willingness to pay directly represent the ability to pay rather than what the valuation should be. De Groot et al. (2012) also pointed out that the valuation from socio-economic contexts is the level of dependence on the resource for critical services. As many poor communities may depend directly on ecosystems for their subsistence such as for the provision of food or clean water. The valuation study that focuses solely on market prices may fail to capture the importance of such services for local livelihoods and cultural values.

4.4 Predicted Value from Meta-Regression

4.4.1 Predicted Value of Thai Forest

The advantage of functional benefit transfer meta-analysis is the use of transferable data from the study site to the policy site. Model 3 was chosen to predict Thai forest values, recall Model 3 equation:

$$lnY_i = \alpha + \beta_1 Forest\ by\ latitude + \beta_2 Methodology + \beta_3 LnPopulation + \beta_4\ LnForest\ Area + \beta_5 LnSocioeconomics$$

Table 4.15 Predicted Thai Forest Values by Scale of Study

Scale of study		**Methodologies**			
		MKT	**CVM**	**TCM**	
Scale 1	**Plot**	4.1438	3.5997	36.4085	*int.$/ha/1000 person*
Scale 2	**Local**	1.3559	1.1779	11.9135	*int.$/ha/1000 person*
Scale 3	**City**	0.4437	0.3854	3.8983	*int.$/ha/1000 person*
Scale 4	**Landscape**	0.1452	0.1261	1.2756	*int.$/ha/1000 person*
Scale 5	**Province**	0.0475	0.0413	0.4174	*int.$/ha/1000 person*
Scale 6	**Country**	0.0155	0.0135	0.1366	*int.$/ha/1000 person*

The result from scale 1 (plot) is between 4.1438 and 36.4085 international dollars per hectare per 1000 person (2017) depending on the valuation method. The result for Scale 6, which is at a country level is between 0.0156 and 0.1366 international dollars per hectare per 1000 person (2017). Adjust the number with the current population in Thailand of around 69.209 million as of 2017 (Worldbank, 2017), the predicted result is between 935 and 9,453 international dollars per hectare. This is in comparable range with the original study cases of Thai forest value per hectare at 194.56 and 28412.72 international dollars, the average value is 5381.73, and the median is around 2457.45 international dollars (E. B. Barbier, 2007; Christensen, 1982; Niskanen, 1998; Seenprachawong, 2002)

CHAPTER 5

CONCLUSION & DISCUSSIONS

5.1 Conclusions

This study attempts to undertake a Meta-analysis on forest valuation. The model in this study takes advantage of the benefit transfer approach by using secondary data from the 'study site' to predict new 'policy site'. In this research, 301 observations were gathered from 81 studies all over the world. The data used in this regressions include 288 observations after eliminating some outliers. The Ordinary Least Square (OLS) regression was adopted in this meta-regression models.

There are five separate models to test which explanatory variables best explain the forest values including forest by latitude, methodologies, and socio economic factors. The first model is set to test the impact of different environmental valuation methodologies on forest values. The result shows that the contingent valuation method and group valuation method, and some marketing method are statistically significant in affecting the value of forests. The second model tests the impact of different types of biome. The results only tropical forest is statistically significant and positive impact on the value of forests. The third model tests how the scale of research impacts forest value. The result shows that the scale of research is highly statistically significant in determining the value of forests. The forth model tests the impact of geographical regions on forest values. The results show that only North America is statistically significant in determining forest values. Lastly, the fifth model tests if forest protection has an influence on forest values. The meta-regression result found that the environmental valuation methodology used, forest types, the scale of research, protected level of the forest, population density, and years of research studied have a significant impact on forest values.

To answer the research questions for this study, the economic values suggested by past published forest valuation studies are relatively consistent. Considering, after follows the guidelines and criteria for data selection 301 observations (data point) was gathered. Only 13 observations (less than five percent) from two studies falls out of the norm and were considered an outlier for this study. The variation of these forest values across studies can be analyzed up by the Meta-analysis. The Meta-regression models used in this study indicate that forest values vary according to forest classification, methodology, geographical location, and socioeconomic background. Meta-analysis is only able to capture the overall picture or trend of forest values. The result of the Meta-analysis shows the mean economic value of forests to be $US8.95 per hectare per 1000 person per year (in 2017).

Meta-regression may not explain why some variables behave the way it did, for instance, why Boreal forest has a negative impact on forest values. As mentioned, the disadvantage of Meta-analysis is that the information from original studies is lost in order to generalize the information to conform to other hundreds of studies. However, when comparing the advantages of Meta-analysis, such as the cost and time efficient, the advantages of Meta-analysis often outweigh its disadvantages.

The second research question asks whether the Meta-analysis of forest values can be applied to forest valuation in Thailand. The Meta-regression was computed back to test the consistency. The Meta-regression model 3 was chosen to predict the value of forest in Thailand. The simulation predicts the value of Thai forest to be between 935 and 9,453 international dollars per hectare. The predicted figures can be adjusted for different scale of study. However, when compared to other benefit transfer methods, there is still a transfer error. Whether this error is acceptable or not depends on the scale of research and its impact on ecosystem values.

This study has satisfied the research objectives by undertaking Meta-analysis to explain forest values. The variations of forest values can be explained by explanatory variables such as ecosystem services, methodology, geographical location, the scale of the study, and socio-economic conditions. With methodologies, it is found that the contingent valuation method and some other marketing methods may explain the forest values better than others. When looking at the global forest values, forest by latitude is a good explanatory variable for both the geographical location and forest types.

The Thai forest values estimated result can be verified with the existing studies. The predicted result of the Meta-analysis shows that the value of Thai forest falls between 935 and 9,453 international dollars per hectare. This is in the comparable range with the actual Thai fore value per hectare at 194.56 and 28,413international dollars.

5.2 Study Limitation

This study only allows the estimate valuation of forest in general range because one of the explanatory variables is methodology. The value of forests, thus, depends on the assumption of which methodology is used for forest valuations. The variation of the results can also widely differ depending on the scale of the research. The limitation of using Meta-analysis is that a substantial amount of information per individual study is loss in the standardization process. Furthermore, the researcher’s decision to keep and drop some of the variables to improve the degree of freedom will also influence the result.

The difficulty in literature review and data collecting is the lack of complete information. Some research studies provide details of all the process and identify affected population, location clearly, while others do not specify types of forest, area of study, or the sample population of that study. Some case studies have different interpretation of forest types when compared to others. Therefore, adjustments are always needed so that the information from different studies conform to in the same format. Some assumptions are needed for those studies that lack data based on further research and country report of that study site.

5.3 Policy implication

Understanding environmental values are vital for policy decision making. Relying on environmental values produced by individual studies can create controversy as the assumptions made as well as methodologies and elicitation techniques used can vary across studies. For example, for recreational valuation studies, the total cost of travel expenses may include accommodation, food, shopping, and opportunity cost of time if not working. Some studies, on the other hand, may disregard the opportunity cost of time by arguing that leisure vocation is included in the workplace. It seems that there are no fixed rules on how this discrepancy should be overcome. Therefore, there is a need for such analysis to compound complex valuations for comprehensive understanding, and meta-analysis can assist that.

For policy makers to make their decision based on a single study can be misleading. The value placed on forest should take into consideration the differences between forest functions, and not only just timber production or net factor income. Quantify the valuation of forest studies into structured systematic procedure can be difficult. However, the benefit of the forest can be valued implicitly through policy decisions.

From Meta-regression result, people place more values on cultural ecosystem services over the market value of provisioning, regulating, or habitat services. Policy implication should be placed on the cultural value of the ecosystem. The cultural ecosystem service, in this case, refers to both the use values of leisure and tourism and the nonuse values. The emphasis and restoration efforts should be focused on forest site that can create recreational values or considered tourist destination such as Khao Yai or Huai Kha Khaeng. The reforestation or afforestation plan can be developed with ecotourism and biodiversity purpose. Further original study research should also be focused on the non-market value of ecosystem services.

There is a need for more economic valuation studies in Thailand especially in areas such as non-market valuation and types of forest such as dipterocarp forest where there is a lack of existing studies. The need to tighten the law for all individuals in order to protect the environment for future generations is imminent and necessary.

There are still continued illegal logging, deforestation, loss of forest in Thailand and all over the world. It is essential for comprehensive valuation studies to respond to the current environmental problem. The future direction of policy implication should aim more towards the sustainable use of natural environment resources (Chase et al., 1998). As there are less available resources, which leads to increasing demand and price of that resources, preserving a natural environmental resource can be 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.

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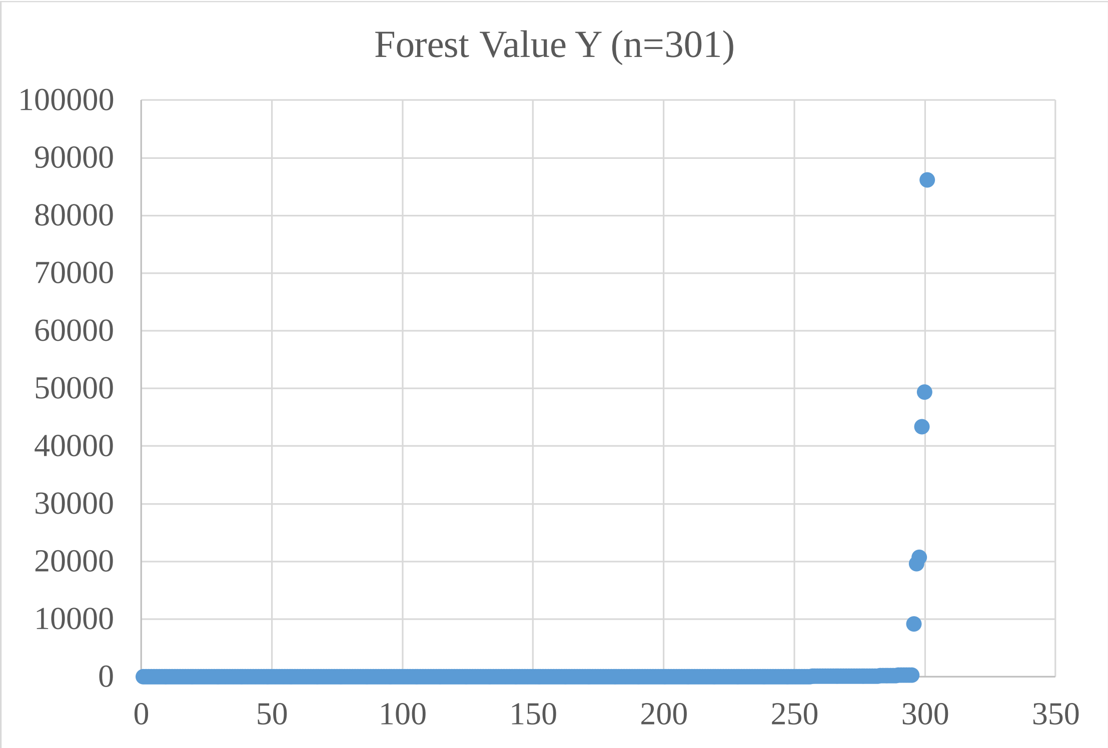
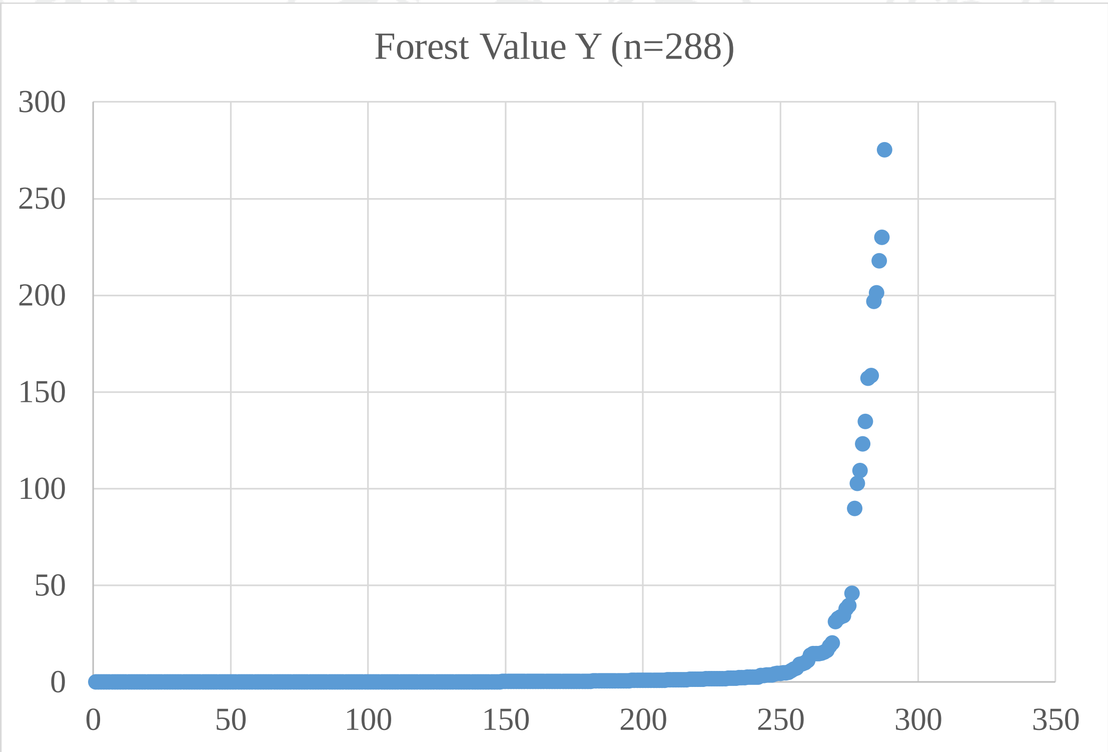
APPENDICES

APPENDIX A: Thailand Forest Area (% of Land Area)

Year	**Forest Area%**	***Source:***
1945	61.00	
1961	53.33	(FAO, 2009); (Lakanavichian, 2006)
1970	47.60	(FAO, 1976)
1973	43.21	(Lakanavichian, 2006)
1975	40.00	(Lakanavichian, 2006)
1976	38.67	(Lakanavichian, 2006)
1978	34.15	(Lakanavichian, 2006)
1982	30.52	(Lakanavichian, 2006)
1985	29.40	(Lakanavichian, 2006)
1988	28.03	(Lakanavichian, 2006)
1989	27.95	(Lakanavichian, 2006)
1990	27.41	(Worldbank, 2017)
1991	28.00	(Worldbank, 2017)
1992	28.59	(Worldbank, 2017)
1993	29.18	(Worldbank, 2017)
1994	29.77	(Worldbank, 2017)
1995	30.35	(Worldbank, 2017)
1996	30.94	(Worldbank, 2017)
1997	31.53	(Worldbank, 2017)
1998	32.12	(Worldbank, 2017)
1999	32.71	(Worldbank, 2017)
2000	33.30	(Worldbank, 2017)
2001	32.94	(Worldbank, 2017)
2002	32.58	(Worldbank, 2017)
2003	32.23	(Worldbank, 2017)
2004	31.87	(Worldbank, 2017)
2005	31.51	(Worldbank, 2017)
2006	31.57	(Worldbank, 2017)
2007	31.63	(Worldbank, 2017)
2008	31.69	(Worldbank, 2017)
2009	31.75	(Worldbank, 2017)
2010	31.81	(Worldbank, 2017)
2011	31.86	(Worldbank, 2017)
2012	31.92	(Worldbank, 2017)
2013	31.98	(Worldbank, 2017)
2014	32.04	(Worldbank, 2017)
2015	32.10	(Worldbank, 2017)
2016	32.16	(Worldbank, 2017)

APPENDIX B: Outliers of the studies





APPENDIX C: Variance Inflation Factor (VIF)

Variance Inflation Factor for Model 1

Variable	**VIF**	**1/VIF**
CVGV	3.36	0.2977
DM	3.28	0.3049
PES	2.49	0.4023
TEMP	2.34	0.4268
LNGDPCAP	2.27	0.4410
MR	2.08	0.4808
AC	1.58	0.6335
TEV_OTH	1.53	0.6521
RC	1.48	0.6742
FI	1.46	0.6848
LNPOPD	1.44	0.6942
BOREAL	1.35	0.7426
CM	1.28	0.7796
LNAREAP	1.25	0.8000
Mean VIF	1.94	

Variance Inflation Factor for Model 2

Variable	**VIF**	**1/VIF**
TROPI	5.11	0.1958
TEMPB	4.98	0.2009
TEMP	2.99	0.3340
WETLC	2.23	0.4477
LNGDPCAP	2.22	0.4505
WETLI	2.20	0.4555
CULTV	1.62	0.6170
BOREAL	1.52	0.6576
CVM	1.42	0.7039
LNAREAP	1.32	0.7557
LNPOPD	1.30	0.7678
TCM	1.28	0.7819
MULTIES	1.25	0.8005
WOODL	1.14	0.8735
Mean VIF	2.19	

Variance Inflation Factor for Model 3

Variable	**VIF**	**1/VIF**
TEMP	2.26	0.4430
LNGDPCAP	2.15	0.4656
CVM	1.30	0.7689
BOREAL	1.29	0.7729
LNAREA	1.29	0.7776
LNPOPD	1.26	0.7927
SCALE	1.24	0.8056
TCM	1.19	0.8425
Mean VIF	1.50	

Variance Inflation Factor for Model 4

Variable	**VIF**	**1/VIF**
DM	5.75	0.1738
PES	5.72	0.1749
ES_REGU	5.35	0.1868
TEMP	5.32	0.1880
ECS	4.96	0.2017
CVGV	4.88	0.2050
MR	4.82	0.2074
TEV_OTH	4.57	0.2187
ES_OTHERS	4.51	0.2217
NAC	3.93	0.2543
LNGDPCAP	3.85	0.2598
ES_PROV	3.51	0.2847
USE	3.13	0.3195
RC	2.88	0.3470
SSF	2.78	0.3603
AC	2.71	0.3696
LCN	2.64	0.3795
LNAREAP	2.59	0.3857
MEA	2.58	0.3881
LNPOPD	2.18	0.4597
BOREAL	2.07	0.4821
FI	1.98	0.5050
SCALE	1.91	0.5223
ES_HABT	1.89	0.5299
CM	1.50	0.6646
SAS	1.32	0.7568
Mean VIF	3.44	

Variance Inflation Factor for Model 5

Variable	**VIF**	**1/VIF**
P_FP	2.62	0.3821
TEMP	2.43	0.4109
LNGDPCAP	2.35	0.4259
P_PP	2.21	0.4535
USE	1.90	0.5277
CVM	1.89	0.5290
SCALE	1.53	0.6522
LNPOPD	1.49	0.6696
LNAREAP	1.39	0.7169
YR	1.34	0.7452
BOREAL	1.32	0.7562
TCM	1.31	0.7657
P_NP	1.15	0.8725
Mean VIF	1.76	

BIOGRAPHY

NAME	Tiparpa Ratisurakarn
ACADEMIC BACKGROUND	Bachelor of Arts (Media Arts), Deakin University, Melbourne, Australia in 2004; Master of Business Administration (Finance), National Institute of Development Administration, Bangkok, Thailand in 2007.
EXPERIENCES	Proposal presentation for Doctoral fieldwork at International Conference on the Regional Innovation and Cooperation in Asia (RICA), Ritsumeikan University, 12-13 October 2018.