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THE ECOSYSTEM SERVICE VALUE OF COASTAL WETLANDS IN DEVELOPING COUNTRIES: A META-REGRESSION ANALYSIS

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Abstract: *Recently, coastal wetland management has become more complex in the context of climate change, increasing human population or per-capita resource consumption, shifting public preferences, increasing resource scarcity, declining environmental health and several other pressures. Hence, it is necessary to design and implement appropriate strategies for sustainable management. Economic valuation can be a powerful tool to aid and improve wise use and wetland management. Yet most valuation techniques are derived from survey research using a large budget and time. A common alternative to new primary studies is the application of benefit transfer through a meta-analysis.*

This paper presents a comprehensive synthesis of coastal wetland valuations and identifies the important factors that determine the value of coastal wetlands through a meta-regression analysis of 838 observations of the economic value of 209 wetlands from 36 countries.The paper is the first to present a meta-regression analysis focused solely on coastal wetland valuation in developing countries.The findings indicate that wetland size has a negative effect on wetland values. Wetland service for water treatment is more valuable than those used for recreation. Wetland values produced by replacement cost are higher than those estimated with other valuation methods.

The meta-regression model is also applied to predict in sample wetland values and the benefit transfer result showed that the overall average and median transfer error amount equal to 27% and 16%, respectively. Based on such results, it appears one suggests that the meta-regression transfer functions can be used to estimate the value of coastal wetlands at policy sites. However, caution is essential when using benefit transfer function to future policy sites across space, time and other dimensions.

Keywords: *Meta-analytical value transfer,ecosystem service valuation, economic valuation, coastal wetlands.*

1. INTRODUCTION

Coastal zones make up just 4% of the world's total land area, and 11% of the total ocean area, yet these zones host more than one third of the world's population (Barbier 2013, Castaño-Isaza et al. 2015). People especially in developing countries depend on the ocean and coasts for their survival and well-being. Coastal and

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marine ecosystems provide many important services to human society, including fisheries production, storm buffering, enhanced water quality, support of tourism and other cultural and spiritual benefits, and maintenance of the basic global life support systems(UNEP 2006). However, population growth and economic development has degraded,or eliminated coastal ecosystems (Barbier *et al.* 2011). Hence, it is necessary to design and implement appropriate strategies for sustainable management (Turner *et al.* 2000, Camacho-Valdez *et al*. 2013).

Economic valuation could potentially assist with assigning values to coastal ecosystem services and thereby aid policy-makers and planners to make effective choices between conservation and conversion of wetlands for sustainable use (Chaikumbung 2013). There are several economic valuation methods to estimate benefit of natural resources. Estimating some ecosystem services such as timber or fisheries can be directly estimated from their market value, but valuing non-market resources (e.g.water treatment, coastal protection, biodiversity support) can be problematic. Non-market valuation methods are necessitated to determine a monetary measure of their value (Woodward and Wui 2001). Nevertheless, most valuation techniques are derived from survey research using a large budget and time.

A common alternative to new primary studies is the application of *benefit transfe*r, whereby information collected from sites is then transferred to unstudied, policy sites. An increasingly common way of conducting benefit transfer is to apply meta-regression analysis (MRA). MRA provides a synthesis of information from several empirical valuation studies, and more importantly can be used to generate benefit transfer functions that are more broadly applicable and less sensitive to the attributes of individual studies (Johnston 2007, Moeltner *et al.* 2007, Chaikumbung *et al.* 2016). Benefit transfer has many potential uses in developing countries, where collecting primary data is impeded by rather limited budgets and unavailable data to estimate the value of the coastal ecosystem services.

However, benefit transfer is subject to three possible sources of errors that affect the precision of benefit transfers are measurement error, publication selection bias and generalization error[1](Rosenberger and Stanley 2006, Eppink *et al.* 2014). Although the reliability and validity of benefit transfer applications remain unclear, it is the best or only option available to inform the policy process and thus will continue to play a role in the field of ecosystem service valuation (Boutwell and Westra 2013, Richardson *etal*. 2015).

There are currently six coastal ecosystem valuation meta-regression analyses: Previous MRA studies have been carried out with a restricted focus on a specific ecosystem type [i.e. coral reefs (Brander *et al.* 2007), lagoon (Enjolras and Boisson 2010) and mangrove (Brander *et al.* 2012, Salem and Mercer 2012), or valuation method, i.e., contingent (Liu and Stern 2008) or ecosystem services i.e. recreation

(Ghermandi and Nunes 2013)] and relying on a quite small sample of value observations. Yet, these MRA studies provide much useful information about the value of the coastal ecosystem services.

The MRA presented in this paper is the first meta-analysis focusing solely on coastal wetlands in developing countries.This can potentially offer a more precise benefit transfer for coastal wetlands in developing countries than a benefit transfer based on data that combines diverse groups of countries. Also it is the first meta-analysis of the coastal wetland literature to explore the issue of publication selection bias. In addition, it conducts the convergent validity test of MRA benefit transfer function using out-of-sample studies from Indonesia and Malaysia.

The paper proceeds as follows. Section 2 discusses MRA methodology. Section 3 details the construction of the meta-dataset used in the MRA. Section 4 presents and analyses the results of MRA models and the final section concludes and summarizes the main findings.

2. THE META-REGRESSION METHODOLOGY

MRA involves summarizing results of existing studies by estimating statistical relationships between values reported in studies to explanatory variables capturing heterogeneity within and across studies. For wetland valuation, MRA uses the summary statistics reported in several prior empirical studies conducted at various sites as the data points for analysis. The dependent variable in the MRA is the natural logarithm of the coastal wetland value per hectare per year at US 2002 constant prices (denoted as lnV). The explanatory variables encompass study characteristics; coastal wetland characteristics, (X_w), valuation methods (X_m), and coastal wetland context (X_c). These variables are discussed in detail in Section 3.

The estimated MRA model takes the following standard semi-logarithmic form:

$$ln V_{ij} = \beta_0 + \beta_w X_{wij} + \beta_m X_{mij} + \beta_c X_{cij} + u_{ij} \qquad (1)$$

Where the subscripts i and j denote the ith estimate from the jth study, β_0 is the constant term, β_w, β_m, and β_c contain the estimated coefficients on the respective groups of explanatory variables, and u is the error term.

There are several issues that need to be addressed in MRA:

2.1. Estimation

The MRA model for this paper uses ordinary least squares (OLS). However, some economists suggest that this can potentially lead to biased estimates, as Eqn. (1) should ideally be estimated employing weighted least squares (WLS). WLS commonly is used in the literature (Mrozek and Taylor 2002, Nelson and Kennedy 2009). Hedges and Olkin(1985) recommend that the inverse variance produces optimal weights. Hence this MRA paper also applies WLS by using the inverse variance as weights. Following Stanley and Rosenberger (2009), using the inverse of the square root of the sample size as a proxy for an estimate's standard error to calculate inverse variance.

Due to the studies included in this meta-dataset reporting multiple estimates[2] per study, the MRA models (both OLS and WLS) presented here uses cluster data analysis and corrects standard errors in the MRA for the clustering of estimates within studies.

2.2. Publication selection bias

Publication selection bias may arise when there is a preference for statistically significant results or for results that conform to the theoretical expectations (Stanley 2008). Publication selection bias can reduce the validity and reliability of meta-regression analyses for benefit transfer (Rosenberger and Stanley 2006).

Stanley and Doucouliagos (2010) suggest a funnel plot that can illustrate and possibly detect the presence of publication selection bias. The funnel plot is a useful graphical method to identify the shape or distribution of reported observations. However, like all graphs, interpretation of funnel plots can be largely subjective. Hence, Stanley (2008) proposed an empirical test - the FAT-PET regression - for testing the existence of publication selection bias which can be tested using the following regression:

$$ln\,\mathrm{V}_{ij} = \beta_0 + \beta_{se}\mathrm{SE}_{ij} + \varepsilon_{ij} \tag{2}$$

where SE denotes the standard error of the effect size under investigation, which in this case is the per hectare wetland value ($\ln V$). Eq. (2) is the standard FAT-PET test that has been applied in a wide range of situations. However, Stanley and Rosenberger (2009) caution against the use of Eq. (2) in the case of willingness to pay studies. These authors argue that if standard error is used it can lead to bias. Instead, Stanley and Rosenberger (2009) recommend replacing SE with the inverse of the square root of the sample size (N):

$$ln\,\mathrm{V}_{ij} = \beta_0 + \beta_{se}(1/\sqrt{\mathrm{N}_{ij}}) + \varepsilon_{ij} \tag{3}$$

If selection bias is detected, then a more general MRA model can be estimated that includes both correction for publication selection bias and heterogeneity:

$$ln\,\mathrm{V}_{ij} = \beta_0 + \beta_w \mathrm{X}_{wij} + \beta_m \mathrm{X}_{mij} + \beta_c \mathrm{X}_{cij} + \beta_{se}(1/\sqrt{\mathrm{N}_{ij}}) + \mathrm{u}_{ij} \tag{4}$$

It should be noted, however, that the example dealt with here differs from the examples dealt with by Stanley and Rosenberger (2009). Nevertheless, the principle of using the inverse of the square root of the sample size to proxy for standard error can be extended to wetland valuations, given that as already noted, standard errors are rarely reported for wetland valuations.

3. THE DATA AND MRA VARIABLES

Data collection and reporting followed the MAER-NET protocols for meta-analysis in economics (Stanley *et al.* 2013).

3.1. Data

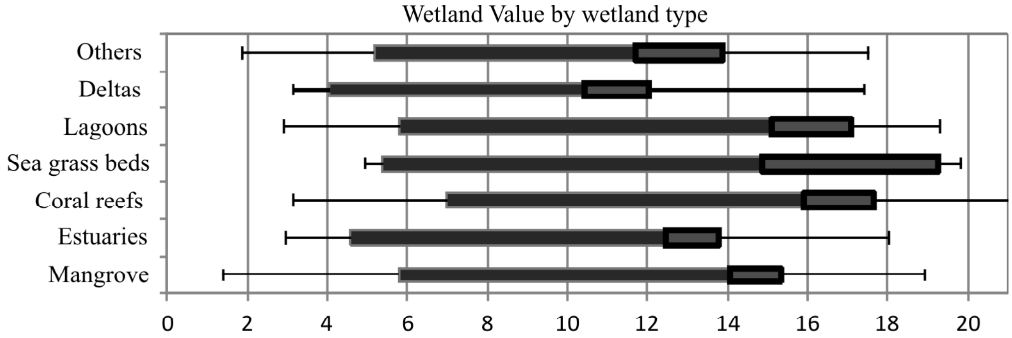
For the purposes of conducting a meta-analysis of coastal wetland values, researcher tried to collect asmuch of the available literature as possible. In total, 209 studies with 838 observations[3] related to coastal wetland valuation were collected. All studies considered are primary valuation studies conducted in developing countries. The studies were collected from book chapters, journal articles, working papers, conference proceeding, project reports, Masters Theses, and Ph.D Dissertations. The earliest study is Christensen's (1982) valuation of Thai mangroves and the most recent study was published in 2015. There are 176 wetland sites included in the data set, spanning 36 developing countries in Asia, Africa, Latin America, and the Pacific Islands. The largest number of studies relate to Thailand (with 27 studies), followed by Malaysia with 25 studies, Philippines with 19 studies, India with 18 studies and Indonesia with 14 studies. The average wetland value is 2,670 US$ (2002 prices) per hectare per annum.

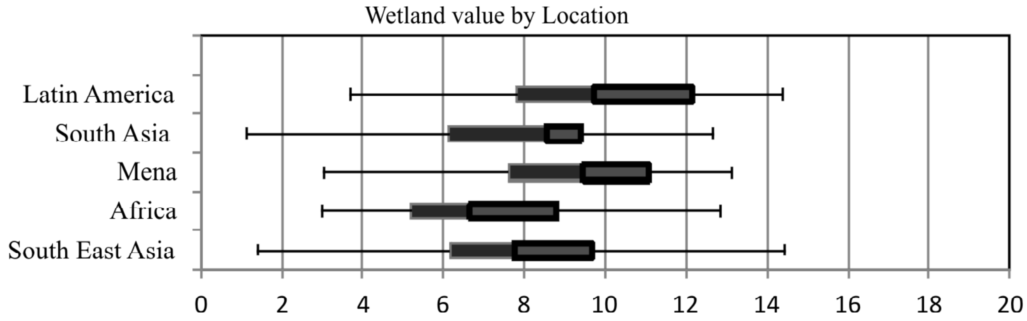
As expected, wetland values vary substantially by wetland types, wetland locations, wetland services and valuation method used. Figures 1illustrate distribution of wetland value for coastal wetland type, location, ecosystem service, and valuation method. The boxes denote values from the first to the third quartile, and the line markers in the bars depict medians. The error bars identify the adjacent values, which are the most extreme values within 1.5 interquartile range (iqr) of the nearer quartile [iqr = the first quartile -the third quartile ($Q_3 - Q_1$)]. Coral reefs have the highest median value, while deltas have the lowest median value. Coastal wetlands in Latin America provide the highest median value. Coastal wetlands in Africa produce the lowest median value. Coastal wetlands providing coastal protection have the highest median value and are also the most widely dispersed. Studies that have used the Net factor income & production function produce the highest median value of wetlands. The lowest median value of wetland is estimated by choice experiment.

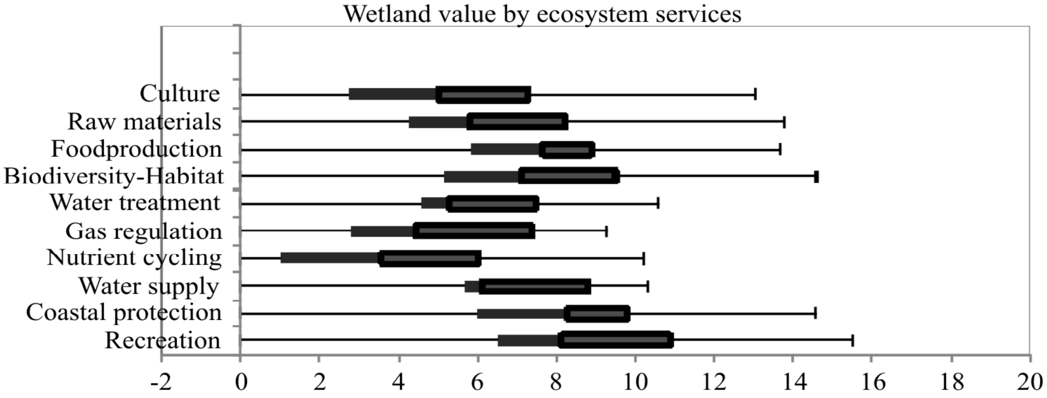
It is expected that a wetland value is determined by is its area.The wetland sites included in the dataset are very diverse. The smallest wetland site is the Ras Mohammed mangrove with 2 hectares from Egypt and the largest is Sibunag mangrove with 783,500 hectares from Philippines. Figure 2 plots wetland size against the wetland value per hectare per annum (both in natural logarithms).

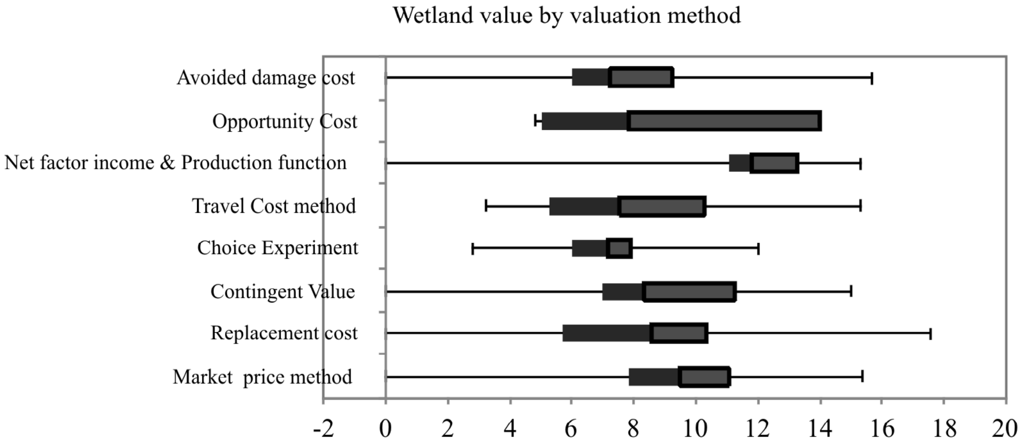
There appears to be relatively negative relationship between wetland value per hectare and wetland area.

It is also expected that another wetland characteristic influencing wetland value is the socio-economic characteristics of its location. Information about income of the relevant population using each wetland was mostly not accessible in the primary studies, so it is proxied by GDP per capita (in year of survey). Differences in per capita GDP might result in differences in wetland values. Figure 2 plots wetland value per hectare per annum against the GDP per capita (both in natural









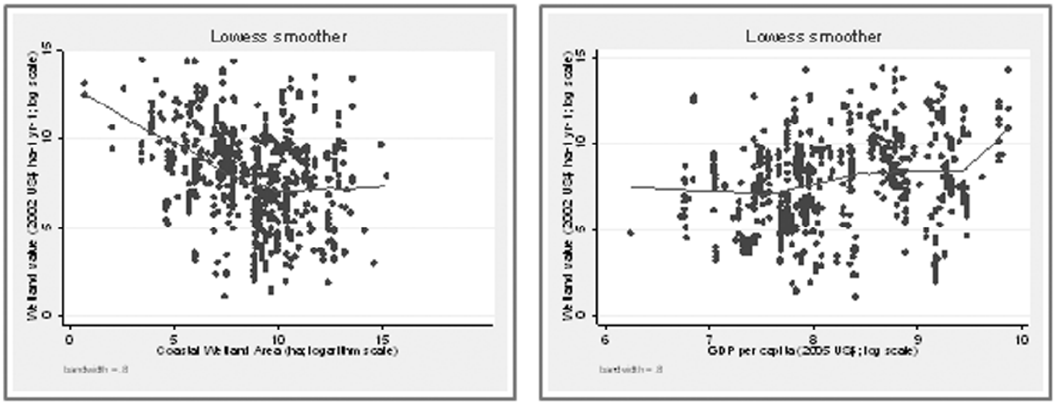


Figure 2: Wetland value per hectare per year plotted against wetland area and GDP percapita

Note: The plotted curve is a lowess regression line

logarithms), suggesting a possible positive relationship between these two variables.

3.2. MRA variables

The names, definitions and descriptive statistics of the variables included in the meta-data set are presented in Table 1.

3.2.1. The dependent variable - the value of wetlands

The wetland values reported by primary studies calculated in different years and expressed in different currencies and metrics (e.g., WTP per household per annum, WTP per visit, mean value per acre per annum and mean value per hectare per annum). Yet, some valuation techniques cannot capture WTP, such as market price method (Mkt), replacement cost (RC), avoided damage cost (DC), net factor income (NFI), opportunity cost (OC), and production function (Pf). On the contrary, if WTP is available, then the value per hectare can be calculated with knowledge of the relevant population and wetland area. Thus, instead of WTP, it is the average annual value per hectare in US$ 2002 that is used as the key value of wetland for this study. Following Woodward and Wui (2001), Brander *et al.* (2006), Ghermandi *et al.* (2010), and Chaikumbung *et al.* (2016) all values of wetlands were converted into a comparable measure using purchasing power indices and expressed in US$ 2002.

3.2.2. The independent moderator

Coastal wetland characteristics vector (x_w)

The key characteristics of wetland sites are wetland size, wetland types and wetland ecosystem services.

Coastal wetland types:

Coastal wetlands were classified into seven types based on the UNEP (2006) definitions. The largest number of studies relate to mangrove with 71 studies and 237 observations) followed by coral reefs with 61 studies and 309 observations and estuaries with 37 studies respectively. For the purposes of the MRA, coral reefs are chosen as the baseline category.

Ecosystem services:

Following the definitions of Barbier *et al.* (1997), Costanza *et al.* (1997) de Groot et *al*. (2002) and Millennium Ecosystem Assessment (2005), coastal ecosystem services were classified into twelve categories.These include: direct use value (food production, raw materials, water supply and recreation),indirect use value (coastal protection,nutrient cycling,carbon sequestration, and water treatment), and non-use value (habitat-biodiversity and culture). The largest number of studies is for food production with 123 studies and 392 observations, followed by recreation with 103 studies and 490 observations and raw materials with79 studies and 231 observations respectively. Recreation is chosen as the baseline category.

Valuation method vector (x_m)

Various economic valuation methods are employed to estimate wetland values in developing countries. These include market-based methods (market price method (Mkt), replacement cost (RC), avoided damage cost (DC), opportunity cost (OC), net factor income (NFI) and production function (Pf)), revealed preference methods (travel cost method (TCM)), and stated preference methods (contingent valuation method (CVM) and choice experiment (CE)). The various methods are grouped into nine techniques, combining NFI and Pf into a single NFI-PF variable. Mkt was the most frequently used method by about 126 studies and 399 observations, followed by contingent valuation method (CVM) with 86 studies and 375 observations, and replacement cost (RC) with 50 studies and 147 observations respectively.

Proxy variables were included for quality of studies along the dimension of published papers and impact factor. However, it is difficult to capture the quality dimension with the ''unpublished paper'' since some of the studies (e.g. Research report or working paper, master thesis and Ph.D. thesis) may be published. The year of survey variable was also included in the meta-dataset to capture possible change of preference in time and temporal effects involving the specific valuation method.

Coastal wetland context vector (x_c)

Coastal wetland context variables were included in the meta-data set; real GDP per capita at constant price 2005, Ramsar site, protected area, urban coastal wetland, population density, latitude and locations. Coastal wetlands in different countries are categorized into the following five groups of locations: Southeast Asian with 115 studies, South Asia with 35 studies, Latin America with 28 studies, Africa with 20 studies, and Middle East Asia and North Africa (MENA) with 11 studies.

4. RESULTS AND DISCUSSION

4.1. Publication selection bias

Table 1
Variable definitions and descriptive statistics

Variable names Dependent variable	*Variable Description*	*Studies*	*Obs.*	*Mean*	*Std.*
Annual value (y)	Annual value per hectare in 2002 US$ in logarithmic form	209	838	7.89	2.66
Independent variables					
Wetland characteristics (x_w)					
Wetland size	Area of wetland site in logarithmic form	209	838	8.46	2.50
Coastal wetland types					
Coral reefs	A large colony of corals including the stony skeletons of both living and dead corals. Baseline category	61	309	0.37	0.48

(*contd...*)

(*Table 1 contd...*)

Variable names Dependent variable	*Variable Description*	*Studies*	*Obs.*	*Mean*	*Std.*
Mangrove	Tropical trees and shrubs grow in the coastal intertidal zone. BD = 1 : Study of mangrove	71	237	0.28	0.45
Estuaries	A semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage. BD =1: Study of estuary	37	112	0.13	0.34
Sea grass beds	Submersed marine grasslike plants grow in shallow coastal waters BD =1: Study of sea grass bed	4	4	0.004	0.07
Lagoons	A shallow body of water separated from a larger body of water by barrier islands or reefs. BD =1: Study of lagoon	8	22	0.02	0.15
Intertidal habitats and deltas	Sedimentary deposit area where the river enters the ocean/ sea BD =1: Study of Intertidal habitats and deltas	11	52	0.06	0.24
Others	All other coastalwetland that cannot be classified on the above criteria (e.g., beach, gulfs, bays and combined coastal wetlands). BD =1: Study of other habitats	17	102	0.13	0.32
Recreation	Providing opportunities for recreational activities (e.g.,eco-tourism, sport fishing and other outdoor recreation activities). Baseline category	103	490	0.48	0.59
Coastal protection	Serving a function as the integrity of ecosystem response to environmental fluctuations such as storm protection, erosion protection and flood control. BD =1: Study of coastal protection	65	181	0.21	0.41
Water supply	Storing water for household consumption and industrial activities. BD =1: Study of water supply	28	14	0.03	0.17
Nutrient cycling	Providing biogeochemical activity	6	9	0.01	0.10

(*contd...*)

(*Table 1 contd...*)

Variable names Dependent variable	*Variable Description*	*Studies*	*Obs.*	*Mean*	*Std.*
	sedimentation ,biological productivity. BD =1: Study of nutrient cycling				
Carbon-sequestration	Regulating the atmospheric chemical composition such as CO2/O2 balance and air quality maintenance. BD =1: Study of carbon sequestration	24	53	.06	.24
Water treatment	Providing nutrient and pollution uptake, as well as retention, particle deposition. BD =1: Study of water treatment	73	17	0.09	0.28
Biodiversity-Habitat	Providing nurseries, habitat for migratory species, regional habitat and degree of life form. BD =1: Study of habitat -biodiversity	89	281	0.34	0.47
Food production	Providing food or primary production, such as production of fish, game, crops, nuts, fruits, and honey. BD =1: Study of food production	123	392	0.47	0.49
Raw materials	Providing gross primary production extractable as raw materials such as lumber, fuel or fodder, reed. BD =1: Study of raw materials	79	231	0.28	0.44
Culture	Providing opportunities for non-commercial uses, such as aesthetic, artistic, education, spiritual and sciences. BD =1: Study of culture	22	16	0.02	0.16
Valuation method(x_m)					
Market price method (Mkt)	Assigns the value of goods and services traded in the market. Baseline category	126	399	0.47	0.49
Replacement cost (RC)	Cost of providing substitutes for ecosystem services. BD =1: Study applies RC	50	147	0.17	0.38
Contingent Value (CVM)	Hypothetical question to obtain WTP. BD=1: Study applies CVM	86	375	0.44	0.49
Choice Experiment (CE)	Estimate WTP based on eliciting individual preferences through survey. BD =1: Study applies CE	11	46	0.05	0.23

(*contd...*)

(*Table 1 contd...*)

Variable names Dependent variable	*Variable Description*	*Studies*	*Obs.*	*Mean*	*Std.*
Travel Cost method (TCM)	Estimate WTP via amount of money and time individuals expend for the visiting recreation site. BD =1: Study applies TCM	24	120	0.14	0.35
Net factor income and Production function (NFIPf)	NFI estimates the value of the environmental service as the change in producer surplus by subtracting the cost of other production inputs from total revenue of the marketable good. Pf measures the change in the quality of ecosystem services and how they affect productivity or production costs. BD =1: Study applies NFIPf	12	55	0.07	0.24
Opportunity Cost (OC)	Value of next best alternative use of resources. BD =1: Study applies OC	7	38	0.05	0.20
Avoided damage cost (DC)	Estimate the expenditure to repair the damage incurred with the loss of the wetland area. BD =1: Study applies DC	44	134	0.16	0.36
Publication status					
Published paper	Study of wetland valuation is published in a journal. BD =1: study is a journal article	84	383	0.46	0.49
Thesis	BD =1: study is thesis /Dissertation	11	62	0.07	0.26
Impact factor	5-year impact factor of each journal	50	290	0.74	1.84
Year of survey	The year of the survey (normalized to the year 2000)	209	838	2.81	5.48
Wetland context characteristics (x_c)					
Protected Area	Wetlands provide any other legal protection by government (e.g. non-hunting area, national park, nature reserve). BD = 1: Study site is protected area	47	261	0.31	0.46
Ramsar site	Ramsar sites are wetlands of international importance, designated under the Ramsar Convention. BD =1: Study site designated as RAMSAR	27	58	0.07	0.25

(*contd...*)

(*Table 1 contd...*)

Variable names Dependent variable	*Variable Description*	*Studies*	*Obs.*	*Mean*	*Std.*
Urban	Wetlands located in urban areas BD =1: Study site is urban wetland	4	9	0.01	0.10
GDP per capita	Real GDP per capita (in year of survey) in logarithmic form for the country in which the wetland is located	209	838	8.38	0.78
Latitude	Latitude in absolute value	209	838	11.20	7.56
Population density	Population densityin logarithmic form	209	838	5.35	1.39
South East Asia	BD =1: wetland located in South East Asia	115	597	0.71	0.45
MENA	BD =1: wetland located in the Middle East and Northern Africa	11	32	0.04	0.19
South Asia	BD =1: wetland located in South Asia	35	70	0.008	0.27
Africa	BD =1: wetland located in Africa, except MENA countries	20	66	0.07	0.28
Latin America	BD =1: wetland located in Latin America	28	73	0.09	0.28

Note: BD denotes a binary variable.

This involves first the construction of funnel plots, and seconds the application of FAT-PET tests. Funnel plots should be symmetric based on the assumptions of underlying data —if the data are not normally distributed, then symmetry is not maintained. Figure 3 is a funnel plot of 693 of the 838 estimates for which sample size is available and, hence, the square root of sample size is used as a proxy for precision. Estimates that are reported with less precision will be distributed at the bottom of the graph. Meanwhile more precise estimates will be located at the top of the funnel plot. Two important points emerge from the funnel plots. First, the funnel plots appear to be symmetrical. There is no obvious truncation or sign of publication bias in this literature. Second, the reported results are highly spread indicating that the results are heterogeneous. This heterogeneity is to be expected given that the meta-datasets include estimates from different countries and from different types of ecosystem services.

The FAT-PET results are reported in Table 2. Columns 1 and 2 present the results using OLS and WLS respectively. The results suggest that there is no evidence of a statistically significant publication selection bias

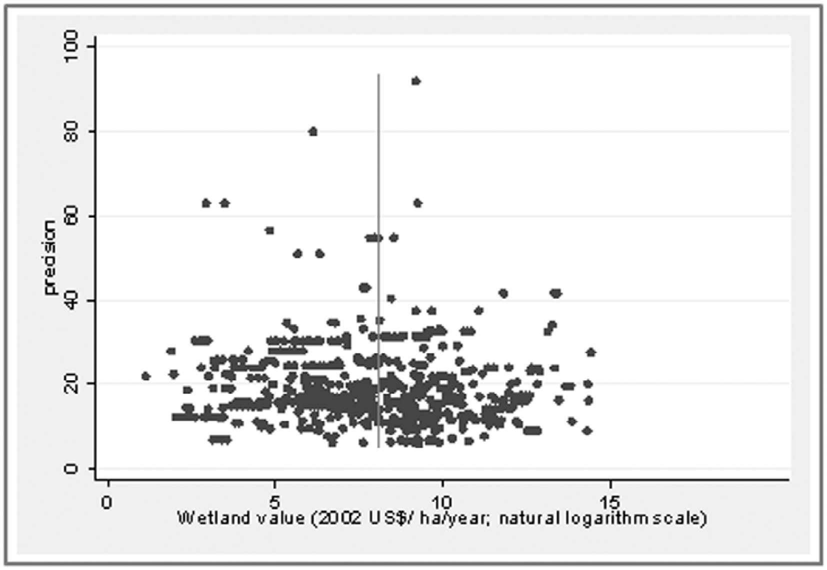


Figure 3: Funnel Plot for wetland valuations

Note: Precision is measured as the square root of sample size.

Table 2
FAT-PET for publication selection and genuine empirical effect
(Dependent variable = Natural logarithm of annual wetland values per ha)

	OLS clustered SESE (1)	*WLS clustered SE(2)*
SE	15.12	12.36
	(9.85)	(12.21)
Constant	6.86***	7.02***
	(0.58)	(0.68)
Adjusted R^2	0.021	0.010
No. of observations	693	693

Figures in brackets are t-statistics. *, ***, denote statistical significance at the 1% and 10% levels, respectively

4.2. MRA results

The meta-regression results are presented in Table 3. Column 1 reports the general model with all moderator variables included estimated using OLS with standard errors adjusted for clustering of observations.These results are the baseline estimates. In column 2, this model reports results of applying a general-to-specific modeling strategy to reducing the MRA to a more parsimonious model, as recommended by Stanley and Doucouliagos (2012). In column 3, this paper use weighted least squares (WLS), using sample size as the weight and Column 4 reports the specific models that are arrived at following a general-to-specific methodology.

The adjusted R^2 value of all models is relatively high varying between 0.43 and 0.54, indicating that close to half of the variation in reported coastal wetland values is explained by the MRA models. The coefficient on area is consistently negative and statistically significant across the models. Similar findings are reported by Enjolras and Biosson (2010), and (Brander *et al.* 2012).This finding possibly reflect the fact that developing countries have a long list of environmental issues and the pressure of substitutes increases the sensitivity of coastal wetland value to coastal wetland size (Chaikumbung *et al.* 2016).

Coastal wetland types significantly affect the value. Mangroves, estuaries,sea grass beds and lagoons habitat produce a lower value than the baseline (coral reefs). One potential explanation for this is that in developing countries, coral reefs are an important source of fisheries products for coastal residents, tourists, and export markets (UNEP 2006). In addition, coral reefs attract a large number of foreign tourists which probably raises the value of this coastal wetland more than average.

Of the coastal ecosystem services, the coefficients on water treatment are consistently positive and highly statistically significant across all models, with the estimates suggesting that coastal wetlands providing services for water treatment have higher values than those used for recreation. Also coastal wetlands supporting for habitat-biodiversity, food production and raw materials have higher values than recreation, but this finding is not always statistically significant. In contrast, the coefficients on carbon sequestration are negative. High, negative values are found also for coastal protection and nutrient cycling even though the respective coefficients are not statistically significant.

The results for the valuation methodology dummy variables indicate that coastal wetland values estimated by replacement cost generate steadily higher values than those estimated by market price method, while value estimates from opportunity cost are consistently lower than estimates from market price method. Also values estimated by the contingent valuation method, choice experiment and travel cost method produce lower valuations than those with market price method, but most these variables are not robustly statistically significant.

On the issue of whether the quality of studies affects wetland value estimates, the published studies tend to report lower values than the unpublished studies. And, the studies published in high impact factor journals tend to estimate lower values than studies published in low impact factor journals.

The coefficient on the year of publication is slightly negative suggests that wetland values have been falling by approximately 6% to 8% annually. This might reflect changes in people's preferences with respect to coastal ecosystem services.

Table 3
MRA of Economic Valuations of Coastal Wetlands, Developing Countries

Variable	*General OLS cluster SE (1)*	*Specific OLS cluster SE (2)*	*General WLS cluster SE (3)*	*Specific WLS cluster SE (4)*
Constant	4.659	3.153	7.084*	10.681***
	(3.097)	(2.745)	(3.759)	(0.976)
Size (lnArea)	0.405***	-0.402***	-0.329**	-0.378**
	(0.095)	(0.086)	(0.107)	(0.096)
Mangrove	-1.572*		-1.099*	
	(0.728)		(0.110)	(0.121)
	(0.867)			
Estuary	-1.941***	-0.961*	-0.677	
	(0.593)	(0.554)	(0.813)	
Sea grass	-2.272*	-1.564*	-3.173	
	(1.039)	(0.755)	(1.408)	
Lagoon	-1.573*		-2.709	-2.065*
	(0.810)		(0.969)	(0.996)
Intertidal habitats and deltas	-1.038		-0.540	
	(0.667)		(0.780)	
Others	-1.069*		-1.661*	-1.629**
	(0.557)		(.658)	(0.506)
Coastal protection	-0.495		-0.059	
	(0.418)		(0.470)	
Water Supply	0.501		-0.141	
	(0.766)		(0.656)	
Nutrient cycling	-0.329		0.341	
	(1.578)		(1.457)	
Carbon sequestration	-0.973*		-2.786***	-1.791**
	(0.476)		(0.668)	(0.571)
Water treatment	1.672***	1.378***	2.081***	2.576***
	(0.439)	(0.453)	(0.581)	(0.516)
Biodiversity-Habitat	0.862*	0.612*	0.303	
	(0.371)	(0.295)	(0.574)	
Food production	1.337**	1.712***	0.288	
	(0.481)	(0.452)	(0.474)	
Raw materials	0.672*		1.303*	1.190**
	(0.375)		(0.594)	(0.396)
Culture	0.214		0.769	
	(0.706)		(1.085)	
RC	0.684*	0.722*	1.384**	1.074*
	(0.411)	(0.433)	(0.509)	(0.496)
CVM	-0.499		-1.004*	-0.846*
	(0.426)		(0.502)	(0.400)

(*contd...*)

(*Table 3 contd...*)

Variable	*General OLS cluster SE (1)*	*Specific OLS cluster SE (2)*	*General WLS cluster SE (3)*	*Specific WLS cluster SE (4)*
CE	-0.152		-0.127	
	(.618)		(0.793)	
TCM	-0.469		-0.129	
	(0.884)		(0.851)	
NFIPf	0.969		0.950	
	(0.767)		(0.904)	
OC	-2.047**	-2.726***	-4.371***	-3.846***
	(0.692)	(0.601)	(0.979)	(0.624)
DC	0.603		1.722***	1.166**
	(0.464)		(0.486)	(0.318)
Impact factor	-0.118		-0.194	
	(0.200)		(0.198)	(0.063)
Published	-0.762	-0.809*	-0.769	-1.082***
	(0.543)	(0.434)	(0.579)	(0.308)
Thesis	-0.207		-0.623	
	(0.696)		(0.702)	
Year of survey	-0.081*	-0.085*	-0.068*	
	(0.031)	(0.033)	(0.029)	
Protected area	1.036*	1.443*	1.166*	1.423***
	(0.491)	(0.570)	(0.562)	(0.438)
Ramsar	0.202		-0.031	
	(0.479)		(0.548)	
Urban	0.270		1.094	
	(1.458)		(1.276)	
ln GDP per capita	0.782*	0.754*	0.566	
	(0.357)	(0.379)	(0.385)	
Absolute Latitude	0.065*	0.068*	0.024	
	(0.034)	(0.022)	(0.039)	
ln Population density	-0.091		-0.203	
	(0.139)		(.165)	
MENA	-0.129		-0.889	
	(1.079)		(1.319)	
South Asia	-0.284		-0.371	
	(0.498)		(0.597)	
Africa	1.315**	1.263**	1.297*	1.302*
	(0.457)	(0.434)	(0.605)	(0.578)
Latin America	0.883	1.418*	1.801*	2.771***
	(0.671)	(0.592)	(0.729)	(0.567)
No. of observations/studies	838/209	838/209	693/177	693/177
Adjusted R^2	0.454	0.429	0.538	0.497

Notes: Figures in brackets are standard errors. *,**, ***, denote statistical significance at the 10%, 5%, and 1% levels, respectively

Coastal wetlands designated as protected areas have a robust higher value than those from other sites. Also coastal wetlands located in urban areas tend to be more valuable than coastal wetlands in rural areas; nonetheless the coefficient on this variable is insignificant. Ramsar sites tend to be less valuable than other sites. However, this finding is not statistically significant.

The coefficient on GDP per capita is positive. Hence, if GDP per capita of a country increases by 1%, wetland values increase by roughly 0.7 %. The MRA results suggest that coastal wetland values in developing countries are income inelastic and also coastal ecosystems are a normal good.

The coefficients on latitude are positive and statistically significant, with the estimates indicating that the value of coastal wetlands might be positively related with the absolute distance from the equator. This result support hypothesis of Brander *et al.* (2006) that the coastal wetland value is possibly related non-linearly (following a parabolic shape) to the absolute distance from the equator.

African and Latin American wetlands are significantly more valuable than South East Asia wetlands. On the contrary, South Asia and MENA wetland tends to be less valuable than South East Asia wetlands, but this finding is not robustly statistically significant.

4.3. Value Transfer

The question remains whether the results from MRA can be used for benefits transfer. Before actually performing a value transfer to a policy site, it is useful to assess the in-sample forecast performance of MRA. In general, the forecast performance of MRA can be assessed using the Mean Absolute Percentage Error (MAPE) to measure the transfer error rate. Obviously, a relatively smaller MAPE indicates better performance of benefit transfer in terms of convergent validity (Shrestha *et al.* 2002). In published benefit transfer studies, "normal" transfer error rates fluctuate between 15% and 75% (Enjolras and Boisson 2010). MAPE is calculated as:

$$MAPE = \left[\left| \frac{V\ observed - V\ estimated}{V\ observed} \right| * 100 \right] \tag{5}$$

where*Vestimated*is the predicted wetland value from MRA models while*V observed* is the reported wetland value in a primary study.

The transfer error rates are computed for each model using a jackknife data splitting.The average MAPE for each OLS and WLS models are about 25.43%to 29.76%, presented in table 4.These mean that on average the transferred values miss the benchmark value by approximately 25% to 30%.

Table 4
The in-sample MAPE of MRA models

MAPE (%)	*General OLS*	*Specific OLS*	*General WLS*	*Specific WLS*	*Average all models*
Average MAPE	25.43	27.07	28.36	29.76	27.65
Median MAPE	13.34	14.48	16.01	17.52	15.34
Maximum	413.91	435.35	420.8	426.5	424.14
Minimum	0.037	0.015	0.005	0.011	0.017

Figures 4 and 5 graph the observed and estimated wetland values and the associated transfer errors, respectively from the general WLS model (column (3) of Table 4).

Although the average MAPE for each model in Tables 4 is probably considered to be quite high, these models perform relatively well when compared to prior meta-studies of coastal wetland valuations. For instance, Brander *et al*. (2007) report a value of 186 %, Liu and Stern (2008) report a value of approximately 12,035%, Emjolras and Boisson (2010) report a value of 87% andSalem and (2012) report average MAPE value of 35%.

Analysis of the average MAPE suggests that the MRA transfer functions can be used to estimate the value of coastal ecosystem services at policy sites, on average. However, caution is suggested in using the MRA transfer function, as some of the individual transfer errors are very large for each MRA model. For example the largest individual transfer errors in General OLS, Specific OLS, General WLS, and Specific WLS models are 413%, 435 %, 420% and 427%, respectively.

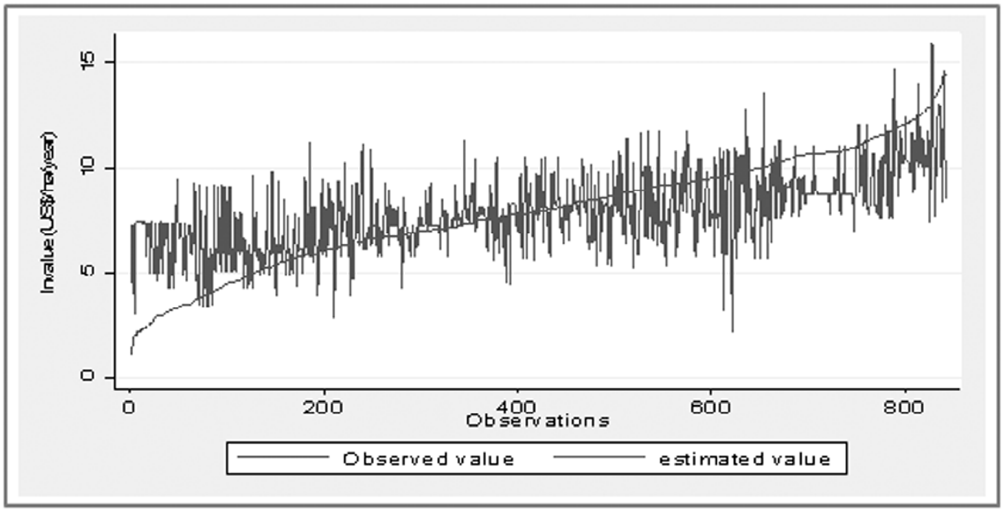


Figure 4: Observed and estimated wetland values

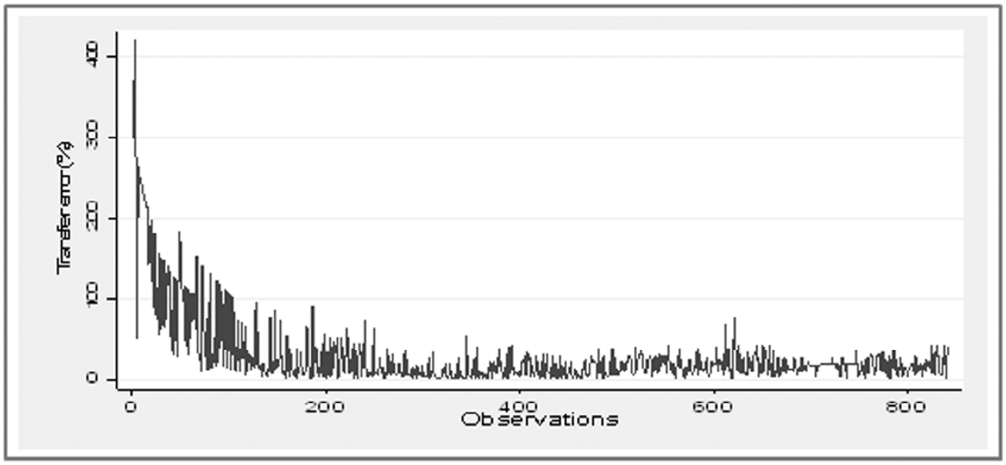


Figure 5: Transfer errors, ranked in ascending order of observed wetland value

4.4. Convergent Validity

Even through the MRA models presented in this paper perform reasonably well for providing a benefit transfer functionin terms of in-sample predictions and absence of publication selection bias, the question remains whether benefit transfer can be used for the policy site. It is necessary to conduct convergent validity tests of benefit transfer function using out-of-sample studies (primary wetland valuation is not used in the derivation of the MRA benefit transfer)(Bergstrom and Taylor 2006, Shrestha *et al*. 2007).

Mangrove[4] in Indonesia and Setiu Wetlands[5] in Malaysia are randomly selected to test convergent validity by comparing benefit transfer estimates of the value of wetlands to estimates based on original value of these wetlands. The original value and estimated benefit transfer value of each coastal wetland presented in table 5.

The precision of benefit transfer is typically measured by Transfer Error (TE). Benefit transfer is obviously more reliable for policy purposes if TE is relatively small. There is no agreement on the maximum TE level for reliable benefit transfer for different policy applications. However, Kristofferson and Navrud(2007) suggest that TE should range between 20% and 40%. This is the range adopted in this paper.TE is calculated as:

$$TE = \left[\left| \frac{V\ original - V\ estimated}{V\ original} \right| * 100 \right] \tag{6}$$

where*V estimated* is the transferred (predicted) wetland value from MRA models while*V original* is the reported wetland value in a primary study.

Table 5
Estimated values of coastal wetlands in Indonesia and Malaysia from MRA transfer functions

Wetland Name	*Valuation methods/ Ecosystem services*	*Benchmark value (Original value) US$/ha/ year at 2002*	*Models*	*Estimated benefit transfer value US$/ha/ year at 2002*	*TE (%)*
Mangrove in Takalar, South Sulawesi, Indonesia	Mkt/RC/DC/ - Food production - Raw materials - Coastal protection - Carbon sequestration	3,214	General OLS	4,156*	29
			Specific OLS	2,272*	29
			General WLS	43	99
			Specific WLS	1,428	55
Mangrove resourcesin Setiu Wetlands, Terengganu, Malaysia	Mkt/ -Raw materials -Food production	417	General OLS	757	82
			Specific OLS	300*	27
			General WLS	301*	27
			Specific WLS	4,984	1,094

Notes: *denotes estimated values close to the original values and TE £ 40%.

As can been seen from Table 5, the original value of mangrove in Indonesia is estimated to be US$ 3,214 per hectare per annum at 2002 prices and General and specific OLS models estimate a value close to the 'original' value of the mangrove in Indonesia which TE scores are less than 40%. Meanwhile, the original benefit of mangrove resources in Malaysia is approximately US$ 417 per hectare per annum at 2002 prices and Specific OLS and General WLS models estimates a value of US$ 300 and US$ 301, respectively which are also close to the original value of mangrove resources. It could be implied that for least these mangroves, Specific OLS model presented in this paper performs relatively better than other MRA models. Thus, this model should be applied to estimate the value of other coastal wetlands at policy site.

5. CONCLUSION

This paper presents a comprehensive overview of coastal wetland valuations in developing countries through a meta-regression analysis of the evidence base to construct a benefit transfer function.The MRA estimations suggest that wetland characteristics, valuation methods, and wetland contexts all influence coastal wetland values.The results indicate that coastal wetland size is very robust in having a negative effect on the value of wetland. Mangroves, estuaries, sea grass beds and lagoons are all regarded as less valuable than coral reefs. GDP per capita has a positive effect on wetland values. Coastal ecosystem services for water treatment are consistently more valuable than those used for recreation. Protected area produce higher values than other sites.The value is estimated by replacement cost technique are higher than other valuation methods.

MRA models presented in this paper perform reasonably well for providing a benefit transfer functionin terms of in-sample predictions and absence of publication selection bias. Thus, it appears that benefit transfer functionis used appropriately in policy decisions. Based on convergent validity tests, Specific OLS model is deemed to be the best estimation applied for policy site, but caution is suggested in using this transfer function to future policy sites across space, time and other dimensions.

Nonetheless, Rosenberger and Phipps (2002) suggest that the precision of value transfer is directly related to the incidence of specific characteristics in the meta-database. Also Rosenberger and Johnston (2011) recommend that researchers can't rely solely on validity, but should adopt indexes e.g. the Biotic Integrity, Welfare Consistency, and other indexes with application of MRA transfer function. Brander *et al* (2012) and Ghermandi and Nunes (2013) integrated the MRA transfer function with spatial data derived from a GIS to estimate values of coastal ecosystems. Such efforts can potentially increase the relevance of primary study out comes and reduce transfer error. Likewise, another effective way toimprove the precision of benefit transfer method is to build a better collection of primary valuation studies that lend themselves to benefit transfer (Plummer 2009).

Although application of benefit transfer model to policy assessments is controversial about its validity and reliability, resource managers and policy analysts still use this method due to constraints in the timeframes and budgets available for planning and management. Nevertheless, applying benefit transfer model needs greater scientific, technical, economic, and other information including to interactions between researchers and policy analysts to generate valid ecosystem service value estimates for support resource management.

Notes

1. Measurement in primary valuation studies may be caused by weak methodologies, unreliable data, analyst; Publication selection bias may occur when there is a preference for statistically significant results or for results that conform to the theoretical expectations, and Generalization error arises from the benefit transfer application to policy sites across time and space.
2. Multiple estimates per study depends on whether they used different methods, wetland sizes, wetland types, sample groups or sought estimates for more than one proposed improvement.
3. An online appendix is available that references the studies.
4. Malik *et al.* (2015)) estimated the value of mangrove in Takalar, South Sulawesi, Indonesia by using Market price method to estimate the value of food production and raw materials, Replacement cost to estimate the benefit of coastal protection of mangrove and Avoided

damage cost to estimate the value of carbon sequestration. The estimated value of mangrove based analysis is $US3,813 per hectare, at 2011 prices.

5 Azmi, M.I (2014) used Market price method to estimate the value of food production and rawmaterials of mangroves resources in Setiu Wetlands, Malaysia. The value of mangrove is $US 541 per hectare, at 2011 prices.

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