Ecosystems and Economic Growth in the Mekong

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Abstract
The Mekong basin is experiencing a period of accelerated economic development. This study compiles available economic valuations of ecosystems in the Mekong basin, estimates robust value ranges, and applies them to the lower Mekong basin to investigate trade-offs made between 2003 and 2010. The comparison of economic losses in ecosystems and gains made in GDP reveals that during this period for every dollar gained in economic growth an average of more than $14 were lost in economic benefits from ecosystem services. These highly unsustainable development pathways mandate a strong commitment to green growth.

Highlights
- This meta study presents ecosystem valuations for the lower Mekong.
- Resulting value ranges can guide development discussion rapidly.
- Between 2003 and 2010 about 57% of annual ecosystem services were lost.
- Compared with GDP gains, ecosystem losses were in average 14 times higher.
- One dollar more GDP coincided with a mean loss of $14.57 in ecosystem services.

Keywords: Mekong; Ecosystem services; Economic valuation; Natural capital; Development.

1 Introduction

For more than a decade the Mekong basin has been experiencing a substantial increase in development investments, largely linked to natural resources (Grumbine et al., 2012; Molle et al., 2009; Smajgl and Ward, 2013b). Key investment sectors involve mining, forestry, agriculture, hydropower and fishing. The utilization and extraction of natural resources involves ecosystems to be degraded if not managed sustainably (Hirsch and Jensen, 2006; Smajgl et al., 2015a; Smajgl et al., 2015b; Ziv et al., 2012). The degradation of ecosystems implies the loss of ecosystem services, which are of high economic value to human societies. Ecosystem services are typically categorized into direct and indirect services, which emphasizes the anthropocentric perspective this utilitarian conceptualization applies (Costanza, 2000; Costanza et al., 1997b; Daily, 1997). Direct services include provisioning, regulatory, and cultural services. Indirect services are typically referred to as supporting services, which an ecosystem receives as necessary support from other ecosystems to maintain its functionality, including nutrient cycling or primary production.

Many development decisions consider the immediate economic return without considering trade-offs, side effects or wider ripple effects (Alcamo et al., 2003; Jakeman and Letcher, 2003; Kandulu et al., 2014; Smajgl et al., 2009). Even from a pure economic perspective the losses in ecosystem services need to be accounted for as otherwise decisions can be made where costs exceed returns, translating in a so-called negative return-on-investment (Chavas, 2000; Smajgl, 2006).

While economic returns are typically instantly revealed as part of the investment offer, the ecosystem-related trade-off usually remains unknown and therefore unconsidered (Chavas, 2000; Connor et al., 2008; Smajgl, 2010; Smajgl et al., 2015c). This creates a substantial risk of resulting in negative return-on-investments. Revealing the economic value of ecosystems and their services involves the implementation of economic valuation methods. Conducting an economic valuation can involve several weeks. Cross-sector discussions, however, take place in much shorter time frames and decisions are often made without adequate assessments (Smajgl and Ward, 2013a, 2015). Thus, the availability of quick estimates can provide critical ad-hoc guidance for understanding the broader economic picture and looming trade-offs.

Providing such first guidance is the goal of this study. The value ranges are based on economic valuation results available for the Mekong basin. Valuations published since 2000 were considered, with most recent results from 2013. The resulting value ranges can be used as per-hectare multipliers for investments involving land cover conversions, typically referred to as benefit transfer (Boyle and Bergstrom, 1992; Brookshire and Neill, 1992). This work does not intend to replace an actual economic valuation. Instead it only aims for the provision of a first guide to understand how economic losses are likely to relate to expected gains. Understanding this proportion highlights the need for an actual economic valuation or even a cost benefit analysis of the decision-making situation at hand.

In addition to establishing robust value ranges for main types of ecosystems, this paper applies these values to the lower Mekong basin to assess the sustainability of recent development.

2 Ecosystem Services

Tansley (1935) was the first to conceptualize ecosystems as “the environment of the Biome – the habitat factors in the widest sense…with which they form one physical system”. More recently, Willis (1997) defined ecosystem as “a unit comprising a community (or communities) of organisms and their physical and chemical environment, at any scale, desirably specified, in which there are continuous fluxes of matter and energy in an interactive open system.”

Both definitions emphasize the dynamic interactions and dependencies. This implies that human habitats consist of many physical (and bio-chemical) factors, which provide an influx of matter and energy and allow for the outflux (or deposition) of material and energy. This dynamic interface can be perceived as services the natural environment provides to human societies.

Ecosystems provide a variety of services, typically categorized as provisioning, regulatory, cultural and indirect services. Provisioning services are the products obtained from ecosystems, including (Scholes et al., 2005, pages 6-13): Food and fiber; Fuel; Genetic resources; biochemicals, natural medicines, and pharmaceuticals; Ornamental resources; Freshwater.

Regulatory services are benefits obtained from the regulation of ecosystem processes, including (Scholes et al., 2005, pages 13-14): Air quality maintenance; Climate regulation; Water regulation; Erosion control; Water purification and waste treatment; Regulation of human diseases; Biological control; Pollination; Storm protection.

Cultural Services are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, including (Scholes et al., 2005, page 14): Recreation and ecotourism; Cultural diversity; Spiritual and religious values; Knowledge systems (traditional and formal); Educational values; Inspiration; Aesthetic values; Social relations; Sense of place; Cultural heritage values.

Indirect ecosystem services are supporting services ecosystems provide to each other. This involves typically fundamental support ecosystems need to deliver the direct services humans benefit from, such a primary production or nutrient cycles. These supporting services gain critical importance if one understands the system-wide dependencies. Typically, supporting services are not considered in economic valuations despite their high relevance for human societies. Given the lack of data this analysis does not account for supporting services. Thus, resulting values underestimate the economic value of ecosystems.

3 Methodology

This study implements a benefit transfer approach (Boyle and Bergstrom, 1992; Brookshire and Neill, 1992; Plummer, 2009) to the lower Mekong basin. In principle, economic valuations of ecosystems employ various methods, including market- based calculations, revealed preference techniques (Travel-cost method, Hedonic price method, Averting investments, Output loss method), and Stated preference techniques (Contingent valuation, Willingness to pay & Willingness to accept, Choice modelling) (Boxall et al., 1996; Sinden, 1994; Willis et al., 1999). This study compiled all available valuation studies conducted since 2000 in the Mekong basin to establish value ranges. Costanza et al. (1997a) implemented a similar approach at the global scale. For the lower Mekong basin 508 data points were considered. Many studies have a strong conservation perspective (e.g. ADB, 2010; Do and Bennett, 2005) while others aim to provide an assessment of the impact of development investments (e.g. Costanza et al., 2011).

The largest number of values (209) was available for evergreen forests, followed by 105 entries for mangroves and 86 results for wetlands. Only 57 values were found for coasts or islands with coral reefs and 51 results for deciduous forests. Annex 1-5 provide the references for all valuation results considered. Most studies provide multiple results as a range of services or aspects of services of a particular ecosystem was valuated. Given the diversity of terminology and methodology these studies deployed their combination into a consistent database required challenging conversion, which involves six steps.

Step 1: In a first step the original documents/studies were reviewed to ascertain the values are correctly derived. Several values obtained in the initial data elicitation phase were identified as incorrect. These mistakes involved mostly wrong multiplication or addition or wrong dimensions (sometimes leading to values inflated or deflated by factor 1,000).

Step 2: Valuations do not apply a consistent classification of ecosystems and ecosystem services. In order to obtain consistent value ranges for total economic value, for provisioning services, regulatory services and cultural services, results needed to be mapped into these broad categories. This step requires a meaningful approach to adding results without double-counting. For instance, many studies quantify the value of non-timber forest products (NTFP) while others valuate individual non-timber forest products. Disaggregated values (i.e. food from forest, raw material from forest) needed to be considered and added-up to be comparable with values for aggregates (i.e. as NTFP).

The mapping affected (1) ecosystems as well as (2) ecosystem services. Ecosystems were mapped into five categories to simplify this analysis:

- evergreen forests,
- deciduous forests,
- wetlands,
- mangroves, and
- coasts or islands with coral reefs.

The majority of valuations followed similar ecosystems types and were mapped accordingly. Some studies were not considered because their aggregates could not be easily mapped into any of these five ecosystems. However, there were data points with uniquely defined categories, including river basin, plantation, terrestrial and marine ecosystems, lake, historic temples, or watershed. In cases where the economic values in its aggregated or in a disaggregated form could not be attributed to either of the five ecosystem types they were not included. Values that focused on specific features that would make any transfer of valuation results into another context difficult (i.e. historic temples) were also excluded. A third group of data that were excluded implies the explicit transformation of landscapes and the replacement of ecosystems (i.e. rice or rubber plantations), which means that ecosystem services would no longer be generated.

The mapping of ecosystem services was important because this analysis aims to provide a total economic value as well as a value for provisioning, regulatory, and cultural services. Hence, results needed to be mapped into these four classes of values. The variety of terms used for ecosystem services and their aggregates created challenges. Despite the availability of global assessments such as the Millennium Ecosystem Assessment, there seems no convergence on a standardized terminology for ecosystem services.

Results were mapped into the three principle services (provisioning, regulatory, and cultural) or included as total economic value. Then the various entries were marked as valuating either the identical/similar aspect or a different aspect of any particular ecosystem. An example for similar terms is “non-timber forest products”, “local non-timber forest products”, and “forest products”. The values for identical/similar aspects were combined in an OR relationship. In other words, among those results that valuate the same or similar ecosystem service the smallest was selected for the minimum value and the highest was selected for the maximum value. Results for different aspects of ecosystem services received an AND relationship. Technically, min/max values consider AND relationships as addition while for OR relationships the smallest/largest value was selected to obtain a meaningful and defensible value range. This approach leads to value ranges for the TEV that are not necessarily identical with the sum of the ranges for provisioning, regulatory and cultural services.

Step 3: The conversion involved three key dimensions: currency, area, and time. This analysis requires a standardized currency to allow results from many studies to be combined in one database. Many publications list economic values in a local currency. The standardized currency chosen is US$. The US$ value was calculated based on the (annual mean) currency conversion factor for the relevant publication year.

Area related conversions involved several aspects. Some cases reported values in national metrics, such as rai for Thailand. All results were converted into a per hectare value to allow for the targeted comparison.

More challenging was the conversion of livelihood-focused results, particularly relevant for forest areas. Many studies report values for households, for instance how much income a household generated from a patch of forest. In a few cases the actual area these households utilized was quantified, which made the conversion into per hectare value easy. In other cases the area was not disclosed, which required a general assumption on area utilized. Otherwise economic values for scarcely populated forests would be very low while densely populated forest areas would be of high economic value. A concept allowing for a standardization is carrying capacity of forests (Arrow et al., 1995; Fearnside, 1985; Keith et al., 2010; Prato, 2001). Based on Daly (1996) an average of 25 households per kilometer square was selected. This is consistent with studies in the database that reported on per household value and on the area utilized by households.

Time-related conversion was required where values were only provided as multi-year results, often discounted. For these cases an annual value needed to be calculated to allow for the targeted meta-study comparison.

Step 4: Comparing economic values over time requires the consideration of price effects as the same amount of money does not allow the purchase of exactly the same amount of goods and services. The increase of prices for the same physical bundle of goods is referred to as inflation while the price reductions over time is referred to as deflation. Introducing these price corrections for valuations since the year 2000 allows utilizing the results in the same value range expressed in today's prices.

For this purpose, the IMF's consumer price index was normalized for the year 2000 with a starting value of 100 in all GMS countries. This results in country-specific coefficients for each year until 2015. A value of 200 for the year 2015 means that for the same bundle of goods and services that cost in 2000 only $100, one would need to pay in 2015 $200. Inflationary effects vary between the GMS countries. As the database does not contain results from valuation exercised in China and Myanmar, price index values were only identified for Cambodia (190.39), Lao PDR (268.31), Thailand (144.32) and Vietnam (308.52). The resulting average is 227.89, which translates into an average annual increase of 8.53. Based on this average, the annual price change was corrected for all values.

It is important to emphasis that this average price index change resembles a linear change. This is different from calculating changes based on annual inflation rates, which would lead to an exponential change if calculated as a year-by-year increase. An average inflation rate of 5.645% leads to the same increase of consumer prices listed above. This approach assumes GMS-wide averages instead of applying country specific price correction because this work aims to inform benefit transfer approaches across the Mekong basin.

Step 5: In a final step, all minimum and maximum values were again checked for consistency, in particular if the calculations considered a meaningful combination and addition of ecosystem service elements. During this process, a few results needed to be corrected or discarded due to inconsistencies. This step involved further consultations with ecosystem service and valuation experts, for instance with IUCN in Bangkok.

Step 6: Considering long-term benefits is typically done as net present values, which translates future benefits into today's value. This involves the application of a social discount rate when converting future benefits. Such a conversion into net present value considers the fact that people have a strong preference for present consumption (Rubinstein, 2003; Sozou, 1998). The longer the benefit is placed in the future the less people value these benefits or costs. However, experiments have shown that the rate by which people discount future benefits drops the further one steps into the future. This means that people see a lot of difference between receiving a benefit now or in one year (hence the need to discount in the first place). But people do not distinguish (much) between receiving a benefit in twelve years or in thirteen years. Therefore, the social discount rate decreases the further one steps into the future. This type of social discounting is referred to as hyperbolic discounting (Rubinstein, 2003; Sozou, 1998). This calculation assumes the following to approximate hyperbolic discounting:

- *for the first 5 years: 4% discount rate*
- *for the ten years thereafter an annual drop of the discount rate by 0.4%*
- *for the ten years thereafter no further discounting is applied*

Most other studies apply the same discount rate for the entire period or apply multiple discount rates for the sake of comparison (e.g. Costanza et al., 2011).

4 Results

The conversion of valuation results (see method section) provides dollar values for the total economic value for one hectare of each main type of ecosystem. This is an annual figure, which means that one hectare of any of the five main ecosystem types is likely to provide every year a total economic benefit that ranges between the minimum and maximum values listed in Table 1.

Table 1: Ranges for annual total economic value for one hectare of main ecosystem types (at 2015 prices)

	Total Economic Value (TEV)		
	MIN	Mean	MAX
Evergreen forest	$7,241	$17,578	$27,916
Deciduous forest	$6,665	$13,306	$19,946
Mangroves	$9,692	$20,324	$30,956
Wetland	$9,906	$12,776	$15,646
Coasts/Islands with coral reefs	$31,235	$44,173	$57,110

Typically, valuations disaggregate total economic value into the three main service dimensions – provisioning, regulatory and cultural services. Table 2 lists the economic value for provisioning services. These values indicate what level of direct benefits communities derive from ecosystems, for instance in the form of tangible products such as non-timber forest products or fish. This translates into household income in the form of traded goods or in the form of subsistence production (or avoided household expense).

Table 2: Value ranges and average value of provisioning, regulatory & cultural services per hectare of main ecosystem types (at 2015 prices)

	Provisioning Services			Regulatory Services			Carbon sequestration		
	MIN	Mean	MAX	MIN	Mean	MAX	MIN	Mean	MAX
Evergreen forest	$2,816	$8,703	$14,589	$4,290	$8,740	$13,191	$135	$135	$135
Deciduous forest	$9,421	$14,131	$18,842	$193	$581	$970	$135	$135	$135
Mangroves	$2,133	$11,661	$21,188	$7,398	$7,881	$8,364	$160	$782	$1,404
Wetland	$324	$2,505	$4,685	$9,580	$10,088	$10,595	$1	$183	$365
Coasts/Islands with coral reefs	$237	$325	$413	$500	$13,350	$26,199	$30,498	$30,498	$30,498

Table 2 also lists the economic value for regulatory services the respective ecosystems provide. The sequestration of carbon is a particular type of regulatory service that plays an important role in international negotiations related to climate change. Economic valuation results vary between $71 and $2,974 (avg. $1,522) per hectare of evergreen forest, between $60 and $837 (avg. $449) for deciduous forests, and between $2 and $245 (avg. $123) for mangroves. Table 2 also summarizes values ecosystems provide in the form of cultural services. The value ranges for this category are narrow if compared to the other results due to the small number of studies that actually considered cultural services.

Above results are annual benefits expressed in 2015-US$ values. However, ecosystems provide these economic benefits in the long-term. Also investments in the replacement or the conservation of ecosystem services have long-term effects. The loss of ecosystems triggers a loss of these long-term benefits, which means that only considering the annual value is misleading. For this analysis a 25 year period was considered to approximate the impact on benefits received by the next generation. It also resembles a typical investment period of hydropower dams or similar infrastructure investments in the Mekong region. The method section explains the conversion to net present values, which follows standard practice. Table 3 summarizes the long-term per hectare value of ecosystems as net present value based on the aforementioned assumptions.

Table 3: Minimum, mean and maximum for Net Present Value for one hectare of main ecosystem types (assuming 25-year period and hyperbolic discounting) (at 2015 prices)

	Net Present Value (NPV) for 25-year period		
	MIN	Mean	MAX
Evergreen forest	$140,224	$340,426	$540,628
Deciduous forest	$129,076	$257,682	$386,288
Mangroves	$187,690	$393,599	$599,507
Wetland	$191,840	$247,421	$303,002
Coasts/Islands with coral reefs	$604,909	$855,465	$1,106,020

5 Development pathways in the lower Mekong basin

In this Section, the meta study results are being applied to the lower Mekong basin to investigate the sustainability of recent development trajectories. The lower Mekong basin is one of the areas within the Mekong region that experiences many controversial debates as development strategies are being implemented at an increasing speed (Molle et al., 2009; Smajgl et al., 2015b). Pro-development arguments are largely substantiated by relatively high annual GDP growth rates, often ranging around 7%. The change in economic value of ecosystems can indicate how sustainable this accelerated growth actually is (Costanza and Farber, 2002; Costanza et al., 1997b).

Kityuttachai et al. (2016) provide the most recent analysis of land cover change, comparing 2003 land cover with the situation in 2010. The categories are slightly adjusted to match the main types of ecosystems listed above. For instance, coniferous forests are listed under deciduous forests as the results of economic valuations in the Mekong basin are similar for both. For the same reason bamboo forest is counted under evergreen forest and flooded forests and marsh/swamp are merged under the wetlands category. Insufficient data was available to robustly analyze changes in economic values of coastal ecosystem services. Thus, the following is only a partial representation of the Mekong basin and is therefore likely to underestimate the total economic value of ecosystems.

Table 4: Total economic value in billion $ for four main ecosystem types in the lower Mekong basin (2003 & 2010; inflation-adjusted at 2015 prices)

	TEV 2003			TEV 2010		
in billion $	MIN	Mean	MAX	MIN	Mean	MAX
Deciduous Forest	$177.3	$354.0	$530.7	$151.0	$301.5	$451.9
Evergreen Forest	$283.3	$687.8	$1,092.3	$63.1	$153.1	$243.2
Wetlands	$10.4	$13.5	$16.5	$8.2	$10.6	$13.0
Mangrove	$3.6	$7.5	$11.4	$1.6	$3.3	$5.0
Total	$459.3	$1,027.7	$1,596.0	$213.3	$446.8	$680.3

Table 4 applies the economic values developed in Section 3 to the land cover data provided by the Mekong River Commission (Kityuttachai et al., 2016). The sharpest reduction results for evergreen forest as large areas of this type of ecosystem were converted into plantations between 2003 and 2010. The area of deciduous forests and wetlands increased according to Kityuttachai et al. (2016) and therefore also the annual value of associated ecosystem services. The mean total economic value of the four main ecosystems dropped from $1,027.7B to $446.8B, which represents a loss of $580.8B (57%). These calculations are inflation adjusted for 2015 price levels. If inflation-correction is not applied and the nominal values are compared for 2003 and 2010 the mean value drops by 29% from $514.3B to $363.5B.

6 Discussion

This study provides a synthesis of economic valuations conducted in the Mekong basin to estimate value ranges and thereby inform negotiations and debates. Considering how rapid many development decisions are being implemented it seems valuable to provide economic estimations quickly to highlight potential trade-offs. It is important to understand the methodological limitations of this study. Taking existing valuation results out of their contexts bears the risk of disregarding important heterogeneity, in particular if the ecosystem at stake is particularly unusual. Any unique feature is likely to increase the real value beyond the estimated maximum value. However, considering the law of large numbers (Sen and Singer, 1993) and the sample size considered in this study these limitations are less problematic if applied to a large area such as the lower Mekong basin.

Several constraints indicate that the results are likely to underestimate the real situation. First, values of ecosystems have only been considered in isolation while ecosystems have to be understood in a broader systems perspective. A wetland, for instance can provide direct benefits to a forest or a lake system, translating into economic benefits for agricultural production or fisheries. These indirect benefits are referred to as supporting services, which this study could not incorporate due to the lack of data. Second, coastal ecosystems – although economically highly valuable – could not be considered due to the lack of data for coastal conversion between 2003 and 2010. Third, value estimates largely abstract from cumulative effects resulting from the conversion of multiple connected areas in the Mekong basin, which is likely to further underestimate the economic value.

Comparing economic values of ecosystems in the lower Mekong basin with GDP is revealing. The annual (total) economic value of ecosystem services depends on the presence of ecosystems. Any conversion of ecosystems for the sake of economic production can only be considered advantageous if the economic value derived from the replacement activity (or production) has a higher value. For instance, replacing forest by a mine site needs to provide annually higher economic returns than provided by ecosystem services. The same holds for the replacement of forests and wetlands by rubber and banana plantations or by other cash crops. This logic suggests comparing annual benefits derived from the economic production system with the changes in annual values derived from ecosystems. Unfortunately, the necessary data is not available to limit this analysis to the actual activities that replaced ecosystems between 2003 and 2010. Instead, GDP is used for the macro-economic perspective.

GDP measures the annual economic value provided by the production of the economic system. Table 5 shows GDP changes for the lower Mekong basin and also provides the disaggregated perspective for the four countries adjusted for the area within the Mekong basin. GDP in the Mekong basin increase from $77.6B to $117.5B (inflation adjusted at 2015 prices).

Table 5: GDP for lower Mekong basin countries in b$ for 2003 and 2010 (at 2015 prices)

	Laos	Northeast Thailand	Vietnam's Mekong delta	Cambodia	Lower Mekong basin
2003	$6.5	$27.5	$100.9	$11.1	$77.6
2010	$14.3	$40.3	$28.5	$12.4	$117.5

Comparing the changes in annual benefits derived from economic production with the annual benefits from ecosystems indicates highly unsustainable development. In average, during this period (2003-2010) the LMB lost for every dollar in GDP growth about $14.57 in ecosystem services (all values inflation adjusted at 2015 prices).

This comparison comes with a few qualifications. First, GDP growth depends on various inputs and the productivity (e.g. per unit of natural capital or per unit of human capital) is not constant. Also, benefit transfer approaches have smaller problems if used for upscaling. But the proportion between areas of a particular ecosystem with low value and those with high value is likely to be different form the sample. Hence, the results can only be indicative and not comprehensive and precise. However, considering the range the conversion ratio ranges from -$6.17 to -$22.98, which suggests that even assuming the lowest economic values for all ecosystems with every dollar increase in GDP more than six dollars were lost in annual values from ecosystem services.

7 Conclusion

This study synthesized economic valuation results for the lower Mekong basin and provides a list of values ranges for the main types of ecosystems. Applying these value ranges to changes recorded for the period 2003-2010 reveals substantial losses of ecosystem services; the economic value that ecosystems provide annually dropped in average by 57% due to land conversions. If compared with GDP changes during the same period these annual economic losses outperform production based gains by factor 14. In other words, for every dollar gained in GDP an average of $14.57 was lost in naturally derived economic benefits. This ecosystem-production conversion loss reveals highly unsustainable development.

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Annex 1: Valuation Results for Evergreen Forest

ADB (2010)	Non-timber forest products; Watershed protection; Water quality regulation; Soil erosion control; Carbon storage;	Cambodia, Laos, Vietnam
Ayumi and Chanhda (2009)		Laos
Bann (1997)	Local non-timber forest products; Forest environmental services	Cambodia
Boscolo (2004)	Fuelwood; Charcoal; Resin	Cambodia
Delang (2005)	Local use of non-marketed wild edible plants	Thailand
Delang (2006)	Local use of non-marketed wild edible plants	Thailand
Emerton et al. (2002b)	Local non-timber forest products	Cambodia
Emerton et al. (2002a)	Local non-timber forest products (cash and subsistence); Commercial non-timber forest products and exports; Local and commercial woodfuel; Legal commercial timber; Local timber; Local fish and aquatic animals;	Laos
Emerton (2005)	TEV; Food, Raw materials, Medicinal resources; Erosion prevention; Regulation of water flows; Moderation of extreme events; Habitat services; Genetic resources; Carbon sequestration	Lao PDR
Grieg-Gran et al. (2008)	Local non-timber forest products	Cambodia
Hansen and Top (2006)	TEV; Non-timber forest products; Sustainable timber; Non-timber forest products; Sustainable timber; Local non-timber forest products; Carbon sequestration; Soil conservation; water conservation; Upland Rice; Eucalyptus; Sugarcane	Cambodia
Heov et al. (2006)	Local non-timber forest products	Cambodia
Hinsui et al. (2008)	Local non-timber forest products cash income	Thailand
Hoa and Ly (2009)	Preservation;	Vietnam
ICEM (2003a)	NTFP; Opportunities for recreation & tourism; Catchment protection; Tourism; Economic value of Ream National Park to local communities; Value of local fisheries; Shells; Local fisheries; Prawns; Marine fish; Crabs; Small shrimp; Lobster; Squid; Freshwater fish; Value of other land and resource use; Firewood; Construction wood; Medicinal plants; Food; Roofing materials; Crops; Livestock; Mangrove conservation; Storm protection; Coastal erosion prevention; Carbon sequestration; Revenues for authorities (fees and parking charges); Tourist earnings for traders at Toek Chou Waterfall; Restaurants; Fruit tables; Shelters; Car parking fees, levies, fees from traders at Toek Chou (Department of Tourism); Motorcycle and car hire, hotels and restaurants (Kampot Town private sector); Taxes from hotels (Tax office); Hydro-electric generation; electricity sales; Value of watershed catchment protection services.	Thailand, Vietnam, Cambodia
Jensen (2009)	Ornamental resources;	Lao PDR
Khonchantet (2007)	Local non-timber forest products (wild vegetable plants, edible mushrooms, bamboo shoots, firewood, fodder, edible insects and ant eggs)	Thailand
Khonchantet 2008	Local fisheries	Thailand
Kuchelmeister (2003)	Watershed services to paddy, to micro-irrigation, and to fisheries; Enhanced paddy productivity; Reduced sedimentation of micro-irrigation facilities; Increased annual fish productivity in small village ponds; Optional values for forest land reserved for tree crop cultivation	Vietnam
Luangmany et al. (2009)	Biodiversity conservation and sustainability	Lao PDR
MARD (2008)	Water regulation for downstream hydropower; Retention of sediment	Vietnam
Nabangchang (2003)	Timber for house construction; NTFP.	Thailand
Phuong and Doung (2007)	Local non-timber forest products	Vietnam
Ratanak and Terauchi (2013)	Rattan;	Cambodia
Rosales et al. (2003)	Local non-timber forest products; Watershed protection	Laos
Rosales et al. 2004	Local non-timber forest products; Flood control	Laos
Rosales et al. (2005)	NTFP; Timber Revenues; Fisheries & aquatic resources; Agricultural Production; Micro-hydropower facilities; Potential hydropower supply; Flood Control; Conservation Expenditures (Biodiversity Conservation); Bioprospecting; Carbon Sequestration.	Lao PDR
The and Ngoc (2006)	Climate regulation, Erosion prevention, Habitat services	Vietnam
To et al. (2012)	TEV; Water, Regulation of water flows; Erosion prevention; Opportunities for recreation & tourism;	Vietnam

Annex 2: Valuation Results for Deciduous Forests

Hansen and Top (2006)	TEV; Non-timber forest products; Carbon sequestration; Soil and water protection	Cambodia
ICEM (2003a)	Housing materials; Firewood; Bamboo shoots; Wild vegetables; Mushrooms; Wild fruits; Deer and wild pigs; Other mammals and reptiles; Birds; Fish; Insects and mollusks; Frogs; Agricultural home consumption; Total home consumption; Wood products (Home consumption); Wild plants (Home consumption); Wild meat and fish (Home consumption); Agriculture (Home consumption); NTFP (Cash income); Wood products (Cash income); Wildlife (Cash income); Agriculture (Cash income); Total NBCA value; Provincial, national and global economic benefits; Watershed catchment protection values; Medium hydro-power potential; Micro hydro-power potential; Irrigated agriculture; TEV; Future economic options for NBCA goods and services; Opportunities for recreation & tourism; Options for the downstream use of water resources; Options for the commercial development of wild species; Carbon sequestration; Tourism; Economic benefits to villages and districts; Value of National Biodiversity Conservation Areas (NBCA) resources for home consumption	Lao PDR, Vietnam
Soussan and Sam (2011)	TEV; Food, Raw materials, Medicinal resources; Water; Regulation of water flows; Erosion prevention	Cambodia

Annex 3: Valuation Results for Mangroves

Bann (1997)	Local fisheries; Local firewood; Local sustainable charcoal	Cambodia
Barbier et al. (2008)	Coastline protection and stabilization	Thailand
Christensen (1982)	Local use	Thailand
Emerton et al. (2002b)	Local subsistence products (excluding fish); Local fisheries.	Cambodia
Emerton (2005)	Food; Moderation of extreme events; Erosion prevention; Carbon Sequestration.	Cambodia
Hoa (2012)	Recreational Value	Vietnam
Kallesøe et al. (2008)	Mangrove products; Fish nurseries.	Thailand
Nhuan et al. (2003)	Timber; Fuel wood; Aquaculture; Marine product collection; TEV; Opportunities for recreation & tourism.	Vietnam
Norman-Lopez et al. (2008)	Timber; Fuel wood; Aquaculture; Organized fishing; Capture fisheries; Tourism.	Vietnam
Phan et al. (2000)	Timber; Firewood; Coal; Non-timber products; Aquaculture; Opportunities for recreation & tourism; Wild animals and plants; Preventing erosion; Mitigating waves and typhoons; Carbon storage; TEV.	Vietnam
Sathirathai (1998)	Local use	Thailand
Sathirathai and Barbier (2001)	Fish; Shrimp; Crab; Mollusks; Honey; Wood.	Thailand
Seenprachawong (2002)	Local use; Non-use values	Thailand
Seenprachawong (2003)	Tourism and recreation	Thailand
Seenprachawong (2008)	Flora and fauna; Recreation and tourism; Local livelihood; Fisheries; Ecological function; Flood protection; Rare and endangered species; TEV; Maintain fish stocks and marine lives.	Thailand
Tri et al. (1998)	Protection against extreme weather events	Vietnam
Tri et al. (2000)	Raw materials; Food; Opportunities for recreation & tourism; Medicinal resources; Habitat services;	Vietnam

Annex 4: Valuation Results for Wetlands

ICEM (2003a)	Shells; Local Fisheries; Nursery protection;	Cambodia, Vietnam
Nhuan et al. (2003)	Timber; Fuel wood; Aquaculture; Marine products; Opportunities for recreation and tourism; TEV; Medical plants; Honey; Stabilising micro-climate; Air quality	Vietnam

	improvents; Water quality; Storm surge protection; Fishing; Coal.	
Chong (2005)	Fish; Aquatic animals; Water birds; Building materials.	Cambodia
Do (2007)	Rice production; Wetland biodiversity.	Vietnam
Do and Bennett (2007a)	Biodiversity	Vietnam
Do and Bennett (2005)	Fuel wood; Mangrove timber; Melaleuca timber; Roofing; Household goods; Freshwater capture fisheries; Shrimp farming; Fish farming.	Vietnam
Do and Bennett (2007b)	Biodiversity	Vietnam
Emerton (2005)	TEV; Fishing; Water for cooking & washing; Transportation; Raw materials; Water; Medicinal resources; Ornamental resources; Food; Opportunities for recreation & tourism; Spiritual experience; Food; Moderation of extreme events; Waste treatment.	Cambodia
Gerrard (2004)	Flood protection; Wastewater treatment.	Laos
Israel et al. (2007)	Freshwater aquatic resources	Cambodia
Muong (2004)	Food	Cambodia
Rab et al. (2006)	Fisheries	Cambodia
Tuan et al. (2009)	Aquaculture; Capture fisheries; Agricultural production; Sea grasses; Fresh water hydrophytes.	Vietnam
Pagdee et al. (2007)	Local use values	Thailand
Pagdee (2008)	Local use values	Thailand

Annex 5: Valuation Results for Coasts or Islands with Coral Reefs

Asafu-Adjaye and Tapsuwan (2008)	Opportunities for recreation and tourism	Thailand
Christiernsson (2003)	Opportunities for recreation and tourism	Thailand
Cushman (2004)	Avoided Litter	Thailand
de Lopez et al. (2001)	Food; Raw materials; Medicinal resources; Opportunities for recreation & tourism; Food; Raw materials.	Cambodia
Doshi et al. (2012)	Opportunities for recreation and tourism	Thailand
Emerton (2005)	Food; Raw material; Medicinal resources	Cambodia
ICEM (2003b)	Total economic value; Fish; Shrimp; Oysters; Compost; Opportunities for recreation & tourism; Education and research	Cambodia, Thailand
Jin et al. (2010)	Conservation of marine turtle	China, Philippines, Thailand, Vietnam
Nam and Son (2001)	Opportunities for recreation & tourism	Vietnam
Nam and Son (2005)	Opportunities for recreation & tourism	Vietnam
Nam et al. (2005)	Opportunities for recreation & tourism; Food	Vietnam
Seenprachawong (2003)	Opportunities for recreation & tourism	Thailand
Seenprachawong (2001)	Tourism	Thailand

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