Bibliography of Coastal and Marine Ecosystem Service Valuation

This bibliography lists the studies relating to the economic valuation of coastal and marine ecosystem services that forms the review of related literature on this topic. The studies are classified according to regions, which include Europe and Central Asia, East Asia and Pacific, Latin America and the Caribbean, North America, South Asia, Sub-Saharan Africa and Global/Multi-Regions. The studies listed here cover the period 1987 to 2015.

1.1 Europe and Central Asia

Ariza Solé, E. (2007). A System of Integral Quality Indicators as a Tool for Beach Management. Laboratori d'Enginyeria Marítima-LIM/ Centre d'Estudis Avançats de Blanes-CEAB, Universitat Politècnica de Catalunya. Doctorate Dissertation (June).

The objective of this study is to develop a system of indicators to measure the integral quality of beaches quantitatively in support of beach managers/decision makers and further creation of guidelines for beach management in the beaches of La Selva Maritima, Costa Brava. The study also identifies the main problems on beaches of the Costa Brava (considered as typical of the Spanish Mediterranean coast) and creates partial indices to characterize different aspects of the beaches. Ranking analysis has shown that in the studied area, those types do not differ so much in global quality. Results obtained for the different partial indices indicate that human pressure in the region is the main factor responsible for the low quality of the surrounding areas and the natural beach communities.

Beaumont, N. J., Austen, M. C., Mangi, S. C., and Townsend, M. (2008). Economic Valuation for the Conservation of Marine Biodiversity. *Marine Pollution Bulletin*, 56(3), 386–396.

This paper presents a goods and services approach to determine the economic value of marine biodiversity in the UK, with the aim of clarifying the role of valuation in the management of marine biodiversity. The goods and services resulting from UK marine biodiversity are detailed, and 8 of the 13 services are valued in monetary terms. The results suggest that this approach can facilitate biodiversity management by enabling the optimal allocation of limited management resources and through raising awareness of the importance of marine biodiversity.

Brander, Luke M., Andrea Ghermandi, Onno Kuik, Anil Markandya, Paulo ALD Nunes, Marije Schaafsma, and Alfred Wagtendonk (2010) "Scaling up ecosystem services values: methodology, applicability and a case study." FEEM.

This paper proposes a methodology for scaling up ecosystem service values to a European level, assesses the availability of data for conducting this method, and illustrates the

procedure with a case study on wetland values. The proposed methodology makes use of meta-analysis to produce a value function that is subsequently applied to individual European wetland sites. Site-specific, study-specific and context-specific variables are used to define a price vector that captures differences between sites and over time. The proposed method is shown to be practicable and to produce reasonably reliable aggregate value estimates.

Brenner, J., Jiménez, J. a., Sardá, R., & Garola, A. (2010). An assessment of the non-market value of the ecosystem services provided by the Catalan coastal zone, Spain. *Ocean and Coastal Management*, *53*(1), 27–38.

In this study, a spatial value transfer analysis was performed to generate baseline estimates of the value of ecosystem services in the coastal zone of Catalonia, Spain. The study used the best available conceptual frameworks, data sources, and analytical techniques to generate non-market monetary value estimates that can be used to identify scarce ecosystem services among competing coastal uses. The approach focused on natural and seminatural, terrestrial and marine systems, which provide essential services that are not considered in current economic markets. Results show that in 2004 a substantial economic value of $3,195 million USD/yr was delivered to local citizens by surrounding ecosystems. In a spatially explicit manner, the approach illustrates the contribution made by natural environmental systems to the well being of communities in the coastal zone of Catalonia. It is hoped that this study will highlight the need to consider these coastal systems in future management strategies to ensure their proper maintenance and conservation.

Cesar, H. S. J. (2000). Collected Essays on the Economics of Coral Reefs. CORDIO, Department for Biology and Environmental Sciences, Kalmar University, SE-392 82 KALMAR, Sweden.

This book brings together the experiences in the economics of coral reefs. It gives to practitioners, decision-makers and academics alike the state-of-the-art thinking on economic aspects of coral reef management. And it shows, through case studies, examples of these aspects in relevant real-life circumstances. Besides, a detailed annotated bibliography gives an overview of the main publications on coral reef threat and stakeholder analyses, economic valuation as well as policy/management issues. The monograph has contributions from reef managers, academics, consultants, NGO-leaders and people from international organisations, each with their own perspectives and experience. The sixteen essays are each focusing on one or more of the four elements (threat analysis, stakeholder analysis, economic valuation, and policy/management), either in general or through specific case studies.

Charles, M. (2005). Functions and Socio - Economic Importance of Coral Reefs and Lagoons Case Study of Moorea, French Polynesia. Department of Environmental Sciences, Wageningen University M.Sc. Thesis, (July 2005).

This paper studies the ecological and socio-economic importance of Moorea´s lagoon-reef system by identifying the diverse functions and their values and the implications for sustainable management. A conceptual framework to define ecosystem valuation is used including a function analysis to describe the specific functions, goods and services provided

by this unique ecosystem and to analyse their availability. Actual and potential services are then taken into account in the socio-economic valuation of these functions and services. Interviews with local experts and a questionnaire based survey of 122 respondents (78 residents and 44 tourists) were conducted in order to investigate the current use of the ecosystem, to measure the importance of the various functions to the respondents, and their Willingness To Pay (WTP) and the Willingness to Participate/Spend Time (WTS) to conserve the marine biodiversity of Moorea's lagoon.

Everard, M. (2009). ***Ecosystem services case studies: Better regulation science programme*****. Environment Agency.**

The UN's Millennium Ecosystem Assessment (MA) integrated various strands of ecosystem service science into a standardised set of "services", generically applicable across habitat types and geographical zones. This MA suite of ecosystem services were grouped into four categories: provisioning services, regulatory services, cultural services and supporting services. The MA strongly advocated the ecosystems approach as a basis for more sustainable policy formulation, highlighting the critical importance of ceasing destructive trends in global ecosystems if we are to secure human wellbeing into the future. In 2007, Defra (the Department for Environment, Food and Rural Affairs) championed uptake of ecosystem services as a basis for more sustainable and inclusive policy formulation in England. The two case studies in this report, one undertaken at catchment scale and the other at site scale, provide learning for the Environment Agency about the applicability of an ecosystems approach to its policies and other activities. The catchment selected was the River Tamar on the Devon/Cornwall border, and the site-scale study was undertaken on the Alkborough Flats managed realignment scheme on the Humber Estuary. These case studies cover historical projects, and seek to evaluate benefits across the suite of ecosystem services reclassified by the MA. The case studies enable generic learning to be taken forwards and, as importantly, help the Environment Agency learn about the benefits of using ecosystem services in its work.

Hussain, S. S., Winrow-Giffin, A., Moran, D., Robinson, L. A., Fofana, A., Paramor, O. A L., & Frid, C. L. J. (2010). An ex ante ecological economic assessment of the benefits arising from marine protected areas designation in the UK. ***Ecological Economics*****,** ***69*****(4), 828–838.**

This paper presents an estimate of the benefits of the proposed designation of a network of marine conservation zones (MCZs) in English territorial and UK offshore waters. This ex ante analysis was undertaken as part of a cost-benefit evidence base to inform implementation of the proposed UK Marine and Coastal Access Bill. This Bill is part of an ambitious plan to designate and manage UK marine areas using an Ecosystems Approach. Benefits are measured in terms of anticipated increases in the value of ecosystem goods and services provisioned by MCZs relative to the counterfactual, i.e. no designation. The principal valuation and thus policy challenge is presented by the need to use benefits transfer in a context where biophysical provisioning functions are not well-developed, where there are gaps in the valuation literature related to temperate marine ecosystem goods and services, and

where values (where available) are presented in aggregate terms. This paper develops and applies a methodology that first apportions these aggregate benefits across the diverse range of marine landscapes and habitats and then estimates the marginal benefit of protection. The value of benefits was calculated for three different configurations of MCZs under two different management regimes. The study questions the extent to which a defensible policy evidence base can be developed in the absence of primary valuation data and where benefit estimates are reported in aggregate terms.

King, S. E., and Lester, J. N. (1995). The Value of Salt Marsh as a Sea Defence. *Marine Pollution Bulletin*, 30(3), 180–189.

In this study the value of salt marsh as a buffer outside sea walls is appraised with reference to the coast of East Anglia in the UK and in particular to that of Essex. As salt marsh width decreases an almost linear increase in wall height is necessitated until loss of a final thin strip causes an exponential rise in maintenance and construction requirements and costs. A minimum value is placed on salt marsh in its capacity as a sea defence and its use and non-use values are discussed. Except in special circumstances salt marsh has a low capital value, and while sale of land to wildfowling syndicates is found to be the highest direct value, this is far surpassed by the indirect value of savings on both capital and maintenance costs in sea defence terms.

Morris, J., & Camino, M. (2011). UK National Ecosystem Assessment Working Paper Economic Assessment of Freshwater , Wetland and Floodplain (FWF) Ecosystem Services. *European Environment*, 78.

This working paper reports on the valuation of ecosystem services from wetlands, freshwaters (rivers and lakes) and floodplains. The focus of economic assessment here is placed on the range of ecosystem goods provided by wetlands, on the goods provided by freswaters in terms of the market and non-market benefits of water quantities and qualities, and the flood regulation services of floodplains. The provision of food and biomass goods by agricultural floodplains and the provision of cultural services associated with freshwater, especially of recreation and amenity, are covered elsewhere.

Nunes, P. A. L. D., Rossetto, L., and de Blaeij, A. (2004). Measuring the Economic Value of Alternative Clam Fishing Management Practices in the Venice Lagoon: Results from a Conjoint Valuation Application. *Journal of Marine Systems*, 51, 309–320.

This article focuses on the economic valuation of alternative clam management practices in the Venice Lagoon. This valuation method, referred in the article as conjoint valuation, gives sufficient flexibility to set, alter, and combine the valuation of different clam management practices. Furthermore, this approach presents an important advantage to the well-known contingent valuation method since it makes the monetary valuation of each management attribute possible.

Pendleton, L. H. (1995). Valuing Coral Reef Protection. *Ocean and Coastal Management*, 26(2), 119–131.

This paper develops an economic framework to show how marine parks and protected areas ought to be valued. An example using data from the Bonaire Marine Park is given. Past economic valuations of tropical marine parks inaccurately measure their economic benefits because they value the resource protected and not the protection provided. Instead, the economic benefit of a marine park should be measured as the savings from avoided losses in reef value that would result in the absence of park protection, net of any costs of protection.

Roebeling, P. C., Costa, L., Magalhães-Filho, L., & Tekken, V. (2013). Ecosystem service value losses from coastal erosion in Europe: Historical trends and future projections. *Journal of Coastal Conservation*, *17*(3), 389–395.

This paper assesses to what extent past and future coastal erosion patterns lead to losses in land cover types and associated ecosystem service values. Hence, historical (based on CORINE land cover information) and projected (based on Dynamic and Interactive Vulnerability Assessment - DIVA - simulations) coastal erosion patterns are used in combination with a benefits transfer approach. DIVA projections are based on regionalized IPCC scenarios. Relative to the period 1975–2050, a case study is provided for selected European coastal country member states. For historical (1975–2006) coastal erosion trends, territory losses are observed in coastal agricultural, water body and forest & semi-natural areas – total coastal erosion equaling over 4,500 km^2. Corresponding coastal ecosystem service values decrease from about €22.3 billion per year in 1975 to about €21.6 billion per year in 2006. It is argued that the response strategy of EU member states to deal with coastal erosion and climate change impacts should be based on the economic as well as the ecological importance of their coastal zones.

Sundberg, Sara. (2004). *Replacement costs as economic values of environmental change: a review and an application to Swedish sea trout habitats*. Beijer International Institute of Ecological Economics.

The objective of this study was to analyse the replacement cost method. For this purpose a number of valuation studies based on replacement costs was reviewed and the method was also applied to value sea trout habitats in Swedish coastal areas. The natural environment supplies goods and a flow of direct and indirect services to society. Economic activity can lead to changes in the flows of these services and the quality of these goods. The value of environmental goods and ecosystem services is not reflected in market prices.

1.2 East Asia and Pacific

Australian Government. (2009). *Economic contribution of the Great Barrier Reef Marine Park 2006-2007*. Great Barrier Reef Marine Park Authority, Australian Goverernment.

This paper estimates the economic and financial value of activities undertaken within the Great Barrier Reef Marine Park Marine Park (GBRMP), Australia for the financial year

2006-07. The total direct and indirect contribution of the GBRMP to the GBRCA is estimated to be just under $3.6 billion in 2006-07. The figure is larger for Queensland at just around $4.0 billion. Australia-wide, the contribution is just over $5.4 billion. These figures correspond with estimated employment contributions, direct and indirect, of 39,700 full time equivalents (FTE) of the GBRMP to the GBRCA. The employment figures for Queensland and Australia are 43,700 and 53,800 respectively. Tourism is by far the largest contributor to economic activity, accounting for 94% of the direct and indirect contribution. Of the remaining activities, fishing, both commercial and recreational, accounts for the bulk of the remaining contribution.

Ahmed, Mahfuzuddin, Gloria Magnayon Umali, Chiew Kieok Chong, Mary Franz Rull, and Marissa C. Garcia. (2007). "Valuing recreational and conservation benefits of coral reefs—The case of Bolinao, Philippines." ***Ocean & Coastal Management*** **50(1): 103-118.**

This study undertakes the valuation of recreational and conservation benefits of coral reefs along the Lingayen Gulf, Bolinao, Philippines using travel cost and contingent valuation methods, respectively. Willingness to pay (WTP) values (in absolute terms and as a percentage of income) for the conservation of coral reefs at Bolinao that were elicited are low, particularly among domestic tourists. This implies that preservation of natural resources and the environment may not be an immediate priority among local travelers due to socio-economic considerations in developing countries, such as the Philippines and the public goods nature of the recreational services provided by coral reefs. These results have further implications for determining the values of coral reefs to support public investment for their conservation and management. The roles of advocacy, education, and awareness campaigns have been highlighted to create a larger WTP for the management of coral reefs.

Bann, Camille. (1999). "A Contingent valuation of the mangroves of Benut, Johor State, Malaysia." ***Economy and Environment Programme for Southeast Asia (EEPSEA).***

This study concerns the Benut mangroves of Malaysia where a contingent valuation was carried out to estimate their biodiversity benefits. The non-use (existence) value put forward by non-Malaysians reveals a very high willingness-to-pay (USD 7,500/ha) for the protection of the mangroves and its biodiversity. The local use benefits from protecting the site in terms of capture fisheries, tourism and shoreline protection were also estimated.

Barbier, Edward B., Ivar Strand, and Suthawan Sathirathai. (2002). "Do open access conditions affect the valuation of an externality? Estimating the welfare effects of mangrove-fishery linkages in Thailand." ***Environmental and Resource Economics*****, 21(4): 343-365.**

This paper develops a “dynamic” production function approach to analyze the influence of habitat changes on an open access fishery that faces a finite elasticity of demand in Thailand. The basic model is applied to a case study of the impacts of mangrove deforestation on the artisanal marine demersal and shellfish fisheries. By estimating parameters through pooled time-series and cross-sectional data over the 1983–1993 period for the five coastal zones of

Southern Thailand, the welfare impacts of mangrove deforestation are estimated under different elasticity of demand assumptions.

Barbier, E. B. (2007). Valuing Ecosystem Services as Productive Inputs. *Economic Policy*, 22(49), 177–229.

This paper explores two methods for valuing ecosystems - the production function approach and the expected damage approach - by valuing the services that they yield to various categories of users and that are not directly valued in the market, and illustrates the usefulness of these methods with an application to the valuation of mangrove ecosystems in Thailand. These two methods are shown to yield very different valuations of ecosystems from those that would be derived by the methods typically used in cost-benefit analyses. It is argued that these methods represent a significant improvement on current practice.

Bennett, E. L., and Reynolds, C. J. (1993). The Value of a Mangrove Area in Sarawak. *Biodiversity and Conservation*, 2(4), 359–375.

This paper presents a case study of the Sarawak Mangroves Forest Reserve in Malaysia.The preservation of tropical forests can be justified using the arguments on economic and employment grounds alone. The mangroves in Sarawak support marine fisheries estimated to be worth USD 21.1 million per annum which also supports up to three thousand jobs. Timber and tourist industries are also estimated to be worth USD 123,217 per annum and USD 3.7 million per annum, respectively. he area is also one of the only remaining refuges for mangrove flora and fauna in Sarawak. If the area were to be converted to aquaculture ponds or oil palm plantations, levels of revenue would be greatly reduced, and the multiple other benefits of mangroves would be lost.

Blackwell, B. D. (2005). The Economic Value of Australia's Natural Coastal Assets: Some Preliminary Findings. Coorperative Research Centre for Coastal Zone, Estuary and Waterway Management, 143–151.

This paper, based on some preliminary findings, reviews the state of knowledge of the value for some coastal ecosystems and has approached the problem of placing an economic value on the EGS of Australia's natural coastal assets from two fronts. First, by undertaking a rapid macro-level assessment using values estimated by Costanza et al. (1997) on a per area basis and multiplying these by the area of Australia's various coastal ecosystems. Second, by collecting data for a micro-based economic assessment in order to eventually compare results with the initial macro-assessment. On a total value basis, Australia's continental shelf appears the most valuable asset, due to its size, followed by open oceans, seagrass beds, estuaries, coral reefs and mangroves. Beach and rocky shore values are yet to be determined.

Bann, C. (1997). An Economic Analysis of Alternative Mangrove Management Strategies in Koh Kong Province, Cambodia. Research Report, Economy and Enviornment Program for South East Asia, Singapore.

This report presents an economic analysis of the different uses of the mangrove resource of Koh Kong province, Cambodia. The objective of the study is to provide information on the

economic benefits and operational practices of key activities in the area that might be employed in the identification of an economically optimal management strategy for the mangrove resource. A parallel objective of the study has been to train a team of Cambodians in survey techniques, data collection and analysis, and ultimately on the economic appraisal of natural resource use. The mangroves in the Koh Kong province of Cambodia, covering an area of 63,700 ha, are ecologically and economically significant to Cambodia and its neighbouring countries. The research focused on the economic valuation of non-timber forest products collected by households from the mangrove area: fuelwood, construction materials, and crabs, shrimp, fish and snails. The charcoal industry, which was active at the time of survey, was also included in this study. The value of local fishing benefits (excluding commercial fishing), fuelwood, relocation compensation are also estimated in this report.

Blackwell, B. (2007). "The ecoservice values for some of Australia's natural coastal assets: how much are our coasts worth and what's missing from the mosaic." In *ANZSEE Conference*, vol. 1, p. EJ.

Taking into account the shortcomings of previous studies examining the value of ecosystem goods and services (ecoservices) provided by Australia's coastal natural resources, this paper attempts to bridge this gap in knowledge by presenting the results from a Coastal CRC project on the matter. When the mosaic of ecoservices for particular coastal ecosystems is created it becomes immediately apparent that any macro-level assessment is not sufficient in capturing the broad spectrum of ecoservice groupings provided by particular biomes, nor the various types of ecoservices within any particular category of ecoservice. The mosaic is far from complete and this paper provides some insights as to what is missing in the previous studies.

Carr, Liam, and Robert Mendelsohn. (2003) "Valuing coral reefs: a travel cost analysis of the Great Barrier Reef." *AMBIO: A Journal of the Human Environment* 32(5): 353-357.

This study examines domestic and international travel to the Great Barrier Reef in order to estimate the benefits the reef provides to the 2 million visitors each year. The study explores the problems of functional form and of measuring travel cost for international visits: comparing actual costs, distance, and lowest price fares. The best estimates of the annual recreational benefits of the Great Barrier Reef range between USD 700 million to 1.6 billion. The domestic value to Australia is about USD 400 million, but the estimated value to more distant countries depends on the definition of travel cost and the functional form. The study conclusively demonstrates that there are very high benefits associated with protecting high quality coral reefs.

Do, T. N., and Bennett, J. (2009). Estimating Wetland Biodiversity Values: A Choice Modelling Application in Vietnam's Mekong River Delta. *Environment and Development Economics*, 14(2), 163.

This study uses choice modelling to estimate the biodiversity protection values of the Tram Chim National Park, a typical wetland ecosystem of the Mekong River Delta in Vietnam, in

an effort to fill the information gap on environmental protection values, especially non-market values. The estimated net social benefit of a proposed protection program ranging from USD 0.52 million to USD 1.84 million suggests that the program's implementation would improve social welfare. Some choice modelling issues, including the use of focus groups, aspects of questionnaire designs, and different survey modes, are discussed in the context of a developing country application.

Fernandez, C. J., Subade, R., & Parreño, P. E. (2007). Will mangrove reforestation provide net benefits: a case in Sibunag, Guimaras. *Science Diliman*, *17*(2).

This study deals with the response to the threats in mangrove resources such as massive fishpond conversion, industrialization, and increased human settlements in coastal areas in Guimaras, Phillippines. The province undertook widespread mangrove reforestation projects in its coastal communities. These projects were found out to be beneficial, as depicted on large gap on the mangroves overall benefits and the costs of implementation of the mangrove reforestation project. Results of the study show that the present total benefit of mangrove per hectare with sustainable harvesting in the first year is lesser than the costs. However after the first year, the net benefits are positive. The net present values (net benefits) of mangrove reforestation were found positive for both scenarios: with sustainable harvesting and without harvesting.

Fernandez, C. J. J., Subade, R. F., & Parreño, P. E. T. (2005). Will mangrove reforestation provide net benefits: a case in Sibunag, Guimaras. *Science Diliman*, *17*(2), 21–38.

This study examines whether the mangrove reforestation project undertaken in the province of Guimaras was beneficial and outweighed costs. Results of the study show that the present total benefit of mangrove per hectare with sustainable harvesting in the first year is lesser than the costs. However after the first year, the net benefits are positive. However, in compliance with Republic Act 7161 (R.A. 7161) that banned the cutting/using of all mangrove species, cost-benefit analysis of mangrove reforestation without harvesting was also computed. The net benefits exceed the costs from the start of the year up to the 20th year. Both the scenarios include the Mean WTP equivalent to PhP 142.75, which is the amount people are willing to give for the conservation of mangroves. The net present values (net benefits) of mangrove reforestation were found positive for both scenarios: with sustainable harvesting and without harvesting.

Janssen, R., and Padilla, J. E. (1999). Preservation or Conversion? Valuation and Evaluation of a Mangrove Forest in the Philippines. *Environmental and Resource Economics*, 14(3), 297–331.

This article compares the costs and benefits of mangrove preservation in Philippines with those generated by alternative uses such as aquaculture and forestry. Equity and sustainability objectives are taken into account, in addition to economic efficiency and analyzed according to the perspectives of the different types of decision makers involved. The aquaculture industry was the single biggest threat to mangroves in the Philippines until 1981 when

conversion of the remaining mangrove stands was prohibited by law. However, the decreasing yield from capture fisheries is putting pressure for the re-examination of this policy. To understand the importance of mangroves, insight is needed into the value of products and services provided is needed.

Lal, P. N. (1990). Conservation or Conversion of Mangroves in Fiji-An Ecological Economic Analysis. Occasional Papers of the East-West Environment and Policy Institute, Paper No. 11, 108.

This study examines the mangrove conversion and use in Fiji and analyses the ecological and economic dimensions of mangrove management actions in the country. It is demonstrated how traditional economic analysis misses many of the important economic benefits associated with healthy mangrove ecosystems and how a broader linked ecological-economic analysis captures many more of the important factors necessary to make informed decisions about mangrove conservation or conversion.

Montenegro, L. O., Remedio, E. M., & Diola, A. G. (2005). *The environmental costs of coastal reclamation in Metro Cebu, Philippines*. Economy and Environment Program for Southeast Asia.

This study examines the case of the Cordova Reclamation Project (CRP), the largest proposed coastal reclamation project in the Philippines. The environmental costs arising from this project were estimated to have a net present value of almost Php 3.3 billion or US$ 59.8 million. This represents about 13 % of the total costs of the reclamation development itself. Environmental costs were estimated from the value of four major environmental impacts: (1) the loss of on-site fisheries; (2) the loss of reef gleaning; (3) the loss of potential recreational benefits from the affected coral reef; and (4) the environmental damage from landfill quarrying. The largest contributing factors to the project's environmental costs were its adverse impacts on coral reefs and the environmental impacts of its quarrying work.

Nam, P. K., & Son, T. V. H. (2001). Analysis of the recreational value of the coral-surrounded Hon Mun islands in Vietnam. *Economy and Environment Programme for Southeast Asia, Tanglin, Singapore. (EEPSEA Research Report Series.)*.

The purpose of this research is to explore the recreational value of the coral-surrounded Hon Mun Islands. The islands contain the richest coral biodiversity in the country and are only about six km from a port, which has been earmarked for expansion. This research employs the travel cost method and the contingent valuation method to measure and analyse impacts on the recreational value of the islands. The zonal travel cost model (ZTCM) estimates the annual recreational value at approximately USD 17.9 million while the result from the individual travel cost model (ITCM) is about USD 8.7 million.

Naylor, R., & Drew, M. (1998). Valuing mangrove resources in Kosrae, Micronesia. *Environment and Development Economics*, *3*(04), 471-490.

This paper, using the revealed preference and contingent valuation methods, analyzes the use and value of mangroves in Kosrae, Micronesia, where the population is largely dependent on

the swamps for fuelwood and other ecosystem services, such as erosion control, storm protection, and nutrient flows to shoreline fisheries. The results show that mangroves on the island are worth between $666 thousand and $1 million per year (1996 prices) based on the net value of marketable products alone. Houshold survey data further indicates that the population places some premium on the existence and indirect ecosystem services of mangroves, over and above the direct use values. Moreover, respondents generally favored—and were willing to pay more for—a tax system designed to manage and preserve the mangroves' direct and indirect services over a permit system focused only the allocation of direct use over time. Additional conclusions regarding the distribution of benefits, with poor households deriving more direct benefits from—but willing to pay less to protect—mangrove ecosystems were also derived.

Nickerson, D. J. (1999). Trade-Offs of Mangrove Area Development in the Philippines. *Ecological Economics*, 28(2), 279–298.

This paper examines the trade-offs of the change in mangrove area use due to the emergence of shrimp culture industry. The trade-offs are examined through three interlinked analyses. The first is a population dynamics model which illustrates the effect of the changes in the habitat (mangrove hectares) to the population of a single mangrove-dependent fish species from the family Leiognathidae. The paper then applies an assumed stock loss scenario from the model to a multiple objective benefit analysis and evaluates the net benefits obtained under three alternatives for the mangrove area: (1) leaving the area undeveloped; (2) developing the area for polyculture; and (3) developing the area for semi-intensive shrimp aquaculture. The procedure in the multiple objective benefit analysis is to classify the benefits to each group affected by the decision and the consequences or net benefits to the groups in aggregate. The results are discussed vis-a-vis social equity issues.

Mohd-Shahwahid, H. O., and McNally, R. (2001). An Economic Valuation of the Terrestrial and Marine Resources of Samoa. The Division of Environment and Conservation, Department of Lands, Survey and Environment, Government of Samoa, and WWF-UK, WWF-South Pacific.

This report, divided into three sections, examines the the basic theory behind the economic valuation of biodiversity in the first section. The second section provides the results from the study, estimating the values of various functions played by Samoa's marine and terrestrial resources. The last section discusses the lessons learned from this economic valuation exercise and reiterates the policy recommendations. Two estimates of the Total Economic Value (TEV) of the goods and environmental services of the forest and marine resources of Samoa were computed.

Pyo, H.-D. (2001). An Economic Analysis of Preservation versus Development of Coastal Wetlands around the Youngsan River. Korea Maritime Institute, 1–42.

This paper addresses the specific benefits and costs for converting coastal wetlands around the Youngsan River in Korea into agricultural use. In conventional BCA excluding passive-use values, two scenarios were employed: in Scenario 1 it is assumed that the effect s of

agricultural production and its air quality improvement occur after 10 years from the beginning of the project. With this optimistic estimate this period is 5 years shorter than the status quo due to the expected technical advances for removing the salt from reclaimed land. Scenario 2 is assumed that the period is normally 15 years without considering the technical changes. Finally, this paper provided a direct and intuitive comparison of total wetland preservation value and total development values for agricultural use.

Ruitenbeek, H. J. (1992). Mangrove Management: An Economic Analysis of Management Options with a Focus on Bintuni Bay, Irian Jaya. Halifax, N.S.: School for Resource and Environmental Studies, Dalhousie University, 1991, 53.

This study is an analysis of the management of mangroves in Indonesia's Bintuni Bay. The sample value estimates of the mangroves was computed to be USD 1500/km^2/yr. Biodiversity benefit from mangroves, commercial forestery, fishery resources along with local traditional uses and imputed benefit of erosion control were also estimated.

Ruitenbeek, H. J. (1994). Modelling Economy-Ecology Linkages in Mangroves: Economic evidence for Promoting Conservation in Bintuni Bay, Indonesia. *Ecological Economics*, 10(3), 233–247.

Woodchip exports pose a potential threat to a 300 000-ha mangrove ecosystem in the Bintuni Bay area of Irian Jaya, Indonesia. The bay supports an important shrimp export industry, and coastal areas support 3000 households. Traditional non-commercial uses of mangroves have an estimated value of Rp20 billion/yr (US$10 million/yr); commercial fisheries are valued at Rp70 billion/yr (US$35 million/yr) and selective commercial mangrove cutting schemes have a maximum value of Rp40 billion/yr (US$20 million/yr). Forest management options, ranging from clear cutting to a cutting ban, are evaluated in a cost–benefit analysis incorporating linkages among mangrove conversion, offshore fishery productivity, traditional uses, and benefits of erosion control and biodiversity maintenance functions. “Linkage scenarios” are developed that reflect potential ecosystem component interactions in Bintuni Bay. Clear cutting is optimal only if linkages are ignored. A cutting ban is optimal if linear and immediate linkages between ecosystem components exist. Under a scenario with linear but delayed linkages of 5 years, selective cutting of 25% of the harvestable mangrove is the optimal strategy; it has a present value of Rp70 billion (US$35 million) greater than the clear cutting option, and more extensive cutting would yield no additional net benefits. Strong economic arguments exist for conservative mangrove clearing. Where strong ecological linkages occur, severe restrictions on clearing activities will be economically optimal. Where ecosystem dynamics are uncertain, programs reducing linkage effects – such as greenbelts, replanting, or selective cutting – will minimise potential economic losses.

Samonte-Tan, G. P. B., White, A. T., Tercero, M. A., Diviva, J., Tabara, E., and Caballes, C. (2007). Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines. *Coastal Management*, 35(2-3), 319–338.

This article provides results on the net benefits generated from the natural resources in the Bohol Marine Triangle (BMT) in the Philippines. Tourism and the municipal fisheries are the

most important direct use values of the coastal and marine resources of the BMT accounting for 44% and 39% of the total net benefits. Annual revenues attributed to ecosystems were as follows: coral reefs, US$1.26 million; beach/intertidal area, US$1.12 million; marine waters, US$646,501; mangrove, US$239,561; and seagrass, US$105,990. The large market values indicate the dependence of the local community on the BMT coastal and marine resources. In the same way, non-market values show the important life-support functions of coastal and marine ecosystems. The net benefits reflect the magnitude of potential losses due to improper management of coastal and marine resources in the BMT. This valuation highlights the importance of the coastal services to the BMT economy and draws attention to the benefits the local stakeholders derive from BMT coastal resources.

Sathirathai, S., and Barbier, E. B. (2001). Valuing Mangrove Conservation in Southern Thailand. *Contemporary Economic Policy*, 19(2), 109–122.

This study undertakes the valuation of mangroves in the face of their conversion for shrimp farming in southern Thailand. The article examines whether or not the full conversion of mangroves into commercial shrimp farms is worthwhile once the key environmental impacts are taken into account. The estimated economic value of mangrove forests to a local community is in the range of $27,264-$35,921 per hectare. The results indicate that, although shrimp farming creates enormous private benefits, it is not so economically viable once the externalities generated by mangrove destruction and water pollution are included. There is also an incentive for local communities to protect mangroves, which in turn implies that the rights of local people to guard and protect this resource should be formally recognized and enforced by law.

Spaninks, F., and van Beukering, P. (1997). Economic Valuation of Mangrove Ecosystems: Potential and Limitations. CREED Working Paper, 14.

The objective of this paper is to review and analyse the scope and limitations of different valuation methods for assessing management alternatives for mangrove ecosystems. The paper compares a range of studies on mangroves with regard to the methodologies employed and the range of products and services valued. It includes a discussion of the benefits of valuation methods for assessing management alternatives, with particular reference to the goods and services of Pagbilao Bay in the Philippines - the study site of the project, Economic Valuation of Mangrove-Fishpond Interactions, for which this paper was written. The literature review and the discussion of the Pagbilao case study illustrate the potential of valuation methods for evaluating management alternatives, as well as the practical limitations to their application. In principle, methods are available but the lack of data and quantitative knowledge regarding some key ecological relationships affirm the need for further inquiry.

Tianhong, L., Wenkai, L., and Zhenghan, Q. (2010). Variations in Ecosystem Service Value in Response to Land Use Changes in Shenzhen. *Ecological Economics*, 69(7), 1427–1435.

This paper studies the variations in values of ecosystem services in response to changes in land-use in Shenzhen, China. A fast evaluation method for ecological service values based on

land use change was proposed and applied to the city for 1996, 2000 and 2004. The evaluation of ecosystem services is conducive to clarifying the ecological and environmental changes caused by urbanization. The objective of this study is to investigate variations in ecosystem services in response to land use changes during urbanization. The aim is to provide useful information and advice for policy makers concerned with sustainable development. The combined ecosystem service value of woodland, wetland, water body and orchard was over 90% of the total value. Water supply and waste treatment were the top two service functions with high service value, contributing about 40% of the total service value. The results suggest that a reasonable land use plan should be made with emphasis on protecting wetland, water body and woodland, which have the highest ecosystem service value.

Tong, C., Feagin, R. A., Lu, J., Zhang, X., Zhu, X., Wang, W., and He, W. (2007). Ecosystem Service Values and Restoration in the Urban Sanyang Wetland of Wenzhou, China. *Ecological Engineering*, 29(3), 249–258.

The main objective of this study was to plan the restoration of the Sanyang wetland, a degraded permanent river wetland that is close to the center of Wenzhou city, China by using both structural indices and a valuation of the wetland's ecosystem services, thereby linking the science to human welfare. Based on field surveys and research into the history of the study area, both the potential and current values of the main ecosystem services were calculated. The results indicated that 89.5% of the service value needs to be restored for the wetland to reach its potential value. It was also recommended that the service provided by the wetland's ability to purify the environment needs to be the top priority in restoration. In addition, water and sediment quality should also be greatly improved.

Tri, Nguyen Hoang, Phan Nguyen Hong, Mr Nguyen Thanh Manh, Mr Le Xuan Tuan, Mr Phan Hong Anh, Mr Nguyen Huu Tho, Ms Nguyen Kim Cuc, Ms Le Huong Giang, and Mr Le Duc Tuan. (2000). "Valuation of the Mangrove Ecosystem in Can Gio Mangrove Biosphere Reserve, Vietnam." The Vietnam MAB National Committee, Hanoi.

This study uses the approach of Total Economic Value (TEV) for the valuation of the mangrove ecosystem in Can Gio Mangrove Biosphere Reserve, Vietnam. The analysis framework of direct use values and non-use values of mangroves which is developed by using Stella 2 dealing with ecosystem services of mangroves in Can Gio is tested. A detailed description of methods estimating the direct value of mangroves is described, including their limitation. Based on Cost-Benefit Analysis, it is presented for each direct benefits/costs: planting, thinning, branching, nipa thatching, propagule supply, in-site and off-site fishing catch, aquaculture, fishing trades and travel cost analysis of eco-tourism. The value of biodiversity conservation is evaluated by using the cost or annual investment from HCMC, considered as the existence value. It is also seen that the limitation of thinning areas, over-

exploitation of fishing catch, water pollution, oil spill among others is contributing towards lower direct benefits, but still higher than the cost.

Tsuge, T., and Washida, T. (2003). Economic Valuation of the Seto Inland Sea by Using an Internet CV Survey. *Marine Pollution Bulletin*, 47(1-6), 230–236.

This paper estimates the economic value of the natural environment damaged in the Seto Inland Sea after the introduction of the Law on Temporary Measures for the Environmental Conservation of the Seto Inland Sea (Setouchi Law) and the value of the natural environment that survived, using a Contingent Valuation (CV) survey. The results indicate that in the 25 years since the introduction of the Setouchi Law, there has been degradation every year about 6.88 trillion yen (58.5 billion dollars) worth of the natural environment by reclaiming. Some seaweed farms and natural shore areas, natural habitats to rare marine life-forms like the horseshoe crab and the fiddler crab have survived, but their value amounts to about 80% of Japan's GDP.

Van den Belt, M., & Cole, A. (2014). Ecosystem goods and services in marine protected areas (MPAs). *Science for Conservation*, 326: 1–96.

This report provides an overview of how ecosystem goods and services (ES) theory, classification, valuation methods and spatial modelling tools can be used to manage and protect New Zealand's existing marine parks, management areas, sanctuaries and the protected area network. Specifically, it summarises the ES of coastal and marine areas, including marine protected areas (MPAs), and provides an estimate of their values, based on a benefit-transfer of values from the literature. The rapid ecosystem services assessment (RESA) method was applied to seven New Zealand marine areas, including the Exclusive Economic Zone (and Territorial Sea), a marine mammal sanctuary and five marine reserves. It is concluded that with an overview of the tools that are being developed for ES valuation, ranging from those that can be applied when the benefits are evident to those that are more suitable for when they are not.

Walpole, M. J., Goodwin, H. J., and Ward, K. G. R. (2001). Pricing Policy for Tourism in Protected Areas: Lessons from Komodo National Park, Indonesia Pricing Lessons Policy for Tourism in Protected Park, Areas: from Komodo National Indonesia. *Conservation Biology*, 15(1), 218–227.

The extent to which ecotourism offsets the costs of a protected area has rarely been examined. This study uses financial data from Komodo National Park, Indonesia, and a willingness-to-pay questionnaire of independent visitors to (1) examine the financial contribution of tourism in offsetting the costs of tourism and wider management and (2) assess the effect of hypothetical fee increases on park revenues, visitation patterns, and local economies. The results suggest that a moderate, tiered increase in entrance fees is most appropriate, and that partial revenue retention by KNP would help demonstrate the conservation value of tourism to both visitors and managers and has the potential to increase visitors' willingness to pay.

Yeo, B. H. (2004). The recreational benefits of coral reefs: a case study of Pulau Payar Marine Park, Kedah, Malaysia: 108-117. *Economic valuation and policy priorities for sustainable management of coral reefs. WorldFish, Penang, Malaysia*.

This study, based on Pulau Payar Marine Park, Kedah, Malaysia, estimated the recreational benefits of the coral reefs at that location. It involved a contingent valuation (CV) study using both face-to-face interviews and self-administrative questionnaires. The willingness to pay (WTP) to access the marine park of visitors to marine park was elicited. The study found that 91 per cent of respondents would accept an entrance fee. The average WTP was estimated at RM$ 16.00 (US$ 4.20). In terms of the tourist numbers recorded during the year of the study, this estimate reflects a potential recreational value of the reefs in the park in the order of RM$ 1.48 million (US$ 390,000) per year. This estimate provides an important indication as to the value of recreational benefits from the coral reefs in Pulau Payar Marine Park.

1.3 Latin America and the Caribbean

Aburto-Oropeza, O., Ezcurra, E., Danemann, G., Valdez, V., Murray, J., & Sala, E. (2008). Mangroves in the Gulf of California increase fishery yields. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(30), 10456–10459.

This study shows that fisheries landings in the Gulf of California are positively related to the local abundance of mangroves and, in particular, to the productive area in the mangrove-water fringe that is used as nursery and/or feeding grounds by many commercial species. The annual economic median value of these fisheries is US $37,500 per hectare of mangrove fringe, falling within the higher end of values previously calculated worldwide for all mangrove services together. The ten-year discounted value of one hectare of fringe is >300 times the official cost set by the Mexican government. Failure to link ecological processes and their societal benefits has favored highly destructive aquaculture and tourism developments that threaten mangroves and result in costly “externalities.” The destruction of mangroves has a strong economic impact on local fishing communities and on food production in the region.

Barbier, E. B., and Strand, I. (1998). Valuing Mangrove-Fishery Linkages: A Case Study of Campeche, Mexico. *Environmental and Resource Economics*, 12(2), 151–166.

This paper explores the value of mangrove systems as a breeding and nursery habitat for off-shore fisheries, focusing on mangrove-shrimp production linkages in Campeche State, Mexico. An open access fishery model is developed in this study to account explicitly for the effect of mangrove area on carrying capacity and thus production. From the long-run equilibrium conditions of the model key parameters are established for determining the comparative static effects of a change in mangrove area on this equilibrium. The effects of changes in the mangrove area in Laguna de Terminos on the production and value of shrimp harvests in Campeche over the period of 1980-90 are also estimated empirically. Over-exploitation of fisheries due to open access conditions remains the more pervasive threat, and

without better management any long-run benefits of protecting the mangrove habitat are likely to be dissipated.

Cesar, H., & Chong, C. K. (2004). Economic Valuation and Socioeconomics of Coral Reefs: Methodological issues and three case studies. *Economic Valuation and Policy Priorities for Sustainable Management of Coral Reefs*, 14-40.

This paper gives an overview of economic valuation (total economic value, cost benefit analysis) and the techniques supporting it (contingent valuation, travel cost, effect on production, etc.) as they are applied to coral reef ecosystems. The paper also highlights some of the socioeconomic issues of reef degradation and conservation and shows the importance of economic issues involved in stakeholder analysis. Stakeholder analysis helps to show who gains and who loses from threats to the coral reef and from conservation measures. Together with economic valuation, it thereby helps to determine what drives unsustainable practices and how such practices can best be mediated given the local social situation. Three case study examples are explored. The first examines the total economic value of a specific area, namely Jamaica, and the costs and benefits of this area when coastal management is introduced. The second demonstrates cost benefit and stakeholder analysis of a threat to coral reefs. The third estimates the economic costs of climate change (coral bleaching, erosion, etc.). The paper concludes with an up-to-date summary of economic valuation studies on coral reefs.

E Copper, LM Burke and ND Bood (2009). Coastal Capital: Belize The Economic Contribution of Belize's Coral Reefs and Mangroves. World Resource Institute, Working Paper, (January).

This paper analyses the economic contribution of Belize's coral reefs and mangroves. It has been estimated that Belize's mangroves provide revenues amounting USD 174-249 million, some independently and some through their supporting role for nearby coral reefs. In 2007, reef and mangrove-associated tourists spent an estimated US$150–$196 million on accommodation, reef recreation, and other expenses (equal to 12–15 percent of GDP). Belize's cruise industry, by comparison, contributes only US$5.3–$6.4 million in reef- and mangrove-related taxes and revenues to the country per year. The negative environmental impacts of cruise tourism disproportionately affect coastal and marine areas, while these areas reap very little economic benefit from the industry. Economic benefits from reef- and mangrove-dependent commercial fisheries are estimated at between US$14–$16 million per year. Belize's fisheries are threatened by over-fishing, especially of desirable finfish such as grouper and snapper, as well as by the loss of healthy coral reef and mangrove habitat. Shoreline Reefs and mangroves protect coastal properties from erosion and wave-induced damage. Belize's coral reefs provide an estimated US$120–$180 million in avoided damages per year. Coastal mangroves offer worth an additional US$111–$167 million per year.

Gammage, S. (1998). Estimating the Returns To Mangrove Conversion: Sustainable Management or Short Term Gain? International Institute for Environment and Development, Environmental Economics Programme, Discussion Paper, 1–81.

This study estimates the total economic value of a mangrove ecosystem in a part of Gulf of Fonseca, El Salvador. The current management strategy is compared to its sustainable counterpart, and to the partial conversion of the mangrove ecosystem to semi-intensive aquaculture and salt ponds. A variety of different valuation techniques are used to assess the contribution of different products and services of the mangrove ecosystem. Among these techniques, a "pseudo production function approach" is used to calculate dose-response estimates of the impact of mangrove loss on the productivity of marine and estuarine fisheries. The valuation exercise yields the result that the sustainable management strategy enables more timber and fisheries benefits to be captured over a horizon of 56 years than do the other management options. This supports the view that the allocation of usufruct rights and the sanctioned conversion of mangrove forest to artificial shrimp ponds reduces the net benefits available to society, and that such policy failures accelerate the loss of biodiversity and compound existing market failures. The research was highly participatory and involved the community in the measurement and articulation of the value of the mangroves.

Mendoza-González, G., Martínez, M. L., Lithgow, D., Pérez-Maqueo, O., & Simonin, P. (2012). Land use change and its effects on the value of ecosystem services along the coast of the Gulf of Mexico. *Ecological Economics*, *82*, 23–32.

The objective of this paper is to analyze land use changes and calculate the value of these changes in terms of lost ecosystem services in the central region of the Gulf of Mexico where urban growth occurs mainly to support tourism and results in loss of natural ecosystems and ecosystem services. Three study sites are selected with contrasting infrastructure for tourism: Boca del Río, Chachalacas and Costa Esmeralda. From 1995-2006, it was found that urban sprawl was predominant, and occurred over mangroves, grasslands, croplands and the beach. Using the benefit transfer method, a net loss ($US 2006/ha/year) of $1.4×103 in Boca del Río, $7×105 in Chachalacas and $1×105 in Costa Esmeralda was calculated. Because the value of urban land is higher (from 45,000 USD/ha (2006) in Costa Esmeralda to 6million in Boca del Río) than the total estimated Ecosystem Services Value (106,000 USD/ha, including all ecosystems and ecosystem services), land use change may seem economically profitable. However, after losing ecosystem services such as coastal protection or scenic value and recreation, the apparent gains from urban development are lost.

Ruitenbeek, J., & Cartier, C. (1999). Issues in applied coral reef biodiversity valuation: results for Montego Bay, Jamaica. World Bank Research Committee Project RPO No. 682-22.

This study using a benchmark value for comparative purposes through the estimates of the net present value (NPV) of readily identified local uses using production valuation approaches in Montego Bay, Jamaica aims to assist policy makers in managing and protecting coral reefs by deriving improved estimates of coral reef economic benefits. The research includes an extensive review of existing biodiversity valuation studies, with a view to identifying appropriate methodological frameworks for marine biodiversity valuation.

Further, this study argues that economic value is dependent on the decision-making, institutional or policy context: there is thus no single biodiversity value that can be attached to any particular reef area. In this light, biodiversity valuation should be regarded primarily as an educational tool to assist policymakers, and secondarily as a planning tool in formulating specific policies.

Ruitenbeek, J., Ridgley, M., Dollar, S., & Huber, R. (1999). Optimization of economic policies and investment projects using a fuzzy logic based cost-effectiveness model of coral reef quality: empirical results for Montego Bay, Jamaica. *Coral Reefs*, *18*(4), 381-392.

The research demonstrates that: (1) it is feasible to use fuzzy logic to model complex interactions in coral reef ecosystems; and, (2) conventional economic procedures for modeling cost-effectiveness can result in sub-optimal policy choices when applied to complex systems such as coral reefs. In Montego Bay, Jamaica, up to a 20% increase in coral abundance may be achievable through using appropriate policy measures having a present value cost of US$153 million over 25 years; a 10% increase is achievable at a cost of US$12 million. Optimization provides insights into the most cost-effective means for protecting coral reefs under different reef quality targets.

1.4 North America

Barbier, E. B., & Enchelmeyer, B. S. (2014). Valuing the storm surge protection service of US Gulf Coast wetlands. *Journal of Environmental Economics and Policy*, *3*(2): 167–185.

In this paper a methodology is developed for estimating the value of wetlands in reducing expected property damages from hurricane flooding that relates damages to the distribution of storm events and incorporates both the wetland characteristics of wave attenuation and offshore storm surge properties. Taking in consideration the current plans for US Gulf Coast wetland resoration which assume that wetlands can save lives and property by reducing storm surges, this methodology is applied to value the storm surge protection service of coastal marshes, in terms of reducing expected property damages, along the path of a storm south-east Louisiana, which includes New Orleans. In conclusion, the implications of this analysis for further research on the economic value of wetlands in protecting coastal property and for restoration policy are discussed.

Bell, F. W. (1989). Application of Wetland Valuation Theory to Florida fisheries. Tallahassee, Florida: Department of Economics, Florida State University.

This report focuses on the evaluation in economic terms of estuarine wetlands to the marine fisheries in Florida. Wetlands provide the carrying capacity for many fishery stocks but, for the most part, are quasi-common property where actual owners cannot capture the implied rental value. This produces a market failure, and great incentive to convert wetlands to uses consistent with organized markets such as residential development and agriculture. The marginal productivity theory is employed for the estuarine wetland valuation.

Bell, F. W. (1997). The Economic Valuation of Saltwater Marsh Supporting Marine Recreational Fishing in the Southeastern United States. *Ecological Economics*, 21(3), 243–254.

This paper attempts to place an economic value on the contribution of wetlands in supporting recreational fishing in the southeastern United States. A production function first links the recreational catch to angler fishing effort and wetlands. The parameters of the recreational fisheries production function are estimated using cross-sectional data by states. To simplify the mathematics, the estimated elasticities are substituted into a Cobb-Douglas production function. For simplicity, a linear demand curve for recreational fishing is postulated which shifts when there is an increase or decrease in the catch (success rate).

Breaux, A., Farber, S., & Day, J. (1995). Using natural coastal wetlands systems for wastewater treatment: An economic benefit analysis. *Journal of Environmental Management*, *44*, 285–291.

This paper reports on estimates of cost savings from using coastal wetlands for substitute treatment in Louisiana, U.S.A. Estimates of discounted cost savings ranged from $785 to $34 700 per acre of wetlands used for treatment. Additional benefits of the use of wetlands as substitues for traditional wastewater treatment include the enhancement in wetlands quality stemming from nutrients in the treated wastewaters.

Cesar, H. S. J., and van Beukering, P. J. H. (2004). Economic Valuation of the Coral Reefs of Hawai'i. *Pacific Science*, 58(2), 231–242.

This paper, without attempting to measure their intrinsic value, shows that coral reefs, if properly managed, contribute enormously to the welfare of Hawaii through a variety of quantifiable benefits. Net benefits are estimated at $360 million a year for Hawaii's economy, and the overall asset value of the state of Hawaii's 1660 km^2 (410,000 acres) of potential reef area in the main Hawaiian Islands is estimated at nearly $10 billion.

Costanza, R., Farber, S. C., and Maxwell, J. (1989). Valuation and Management of Wetland Ecosystems. *Ecological Economics*, 1(4), 335–361.

This paper discusses the fundamental theoretical and practical problems underlying natural resource valuation and summarizes the methods and findings for Louisiana wetlands. It also elaborates on some of the more recalcitrant problems attending applied natural resource valuation, including discounting and dealing with uncertainty and imprecision. The discount rate makes more difference in the final result than any other one factor, and yet there is much disagreement about the appropriate approach to discounting natural resources. The discounting problem is discussed as applied to natural resources and argument for lower discount rates for valuing renewable natural resources than apply for other aspects of the economy is raised.

Costanza, R., Wilson, A., Troy., A., Voinov, A., Liu, S. (2006). The Value of New Jersey's Ecosystem Services and Natural Capital. *Institute for Sustainable Solutions*.

This report summarizes the results of a two-year study of the economic value of New Jersey's natural capital. The benefits provided by natural capital include both goods and services; goods come from both ecosystems (e.g., timber) and abiotic (non-living) sources (e.g., mineral deposits), while services are mainly provided by ecosystems. This report focuses on the services provided the state's ecosystems, covering twelve different types of ecosystem and twelve different ecoservices in New Jersey. As a way of expressing these relative values or "trade-offs", this study estimated the dollar value of the ecoservices produced by New Jersey's ecosystems. In deriving these estimates, they used three different approaches: value transfer, hedonic analysis, and spatial modeling.

Costanza, R., Pérez-Maqueo, O., Martinez, M. L., Sutton, P., Anderson, S. J., & Mulder, K. (2008). The value of coastal wetlands for hurricane protection. *AMBIO: A Journal of the Human Environment, 37*(4), 241-248.

This paper studies the reduction of damaging effects of hurricanes on coastal communities due to the presence of coastal wetlands. In this study, a regression model using 34 major US hurricanes since 1980 with the natural log of damage per unit gross domestic product in the hurricane swath as the dependent variable and the natural logs of wind speed and wetland area in the swath as the independent variables showed highl significance and explained 60% of the variation in relative damages. A loss of 1 ha of wetland in the model corresponded to an average USD 33,000 (median = USD 5000) increase in storm damage from specific storms. Using this relationship, and taking into account the annual probability of hits by hurricanes of varying intensities, the annual value of coastal wetlands by 1 km x 1 km pixel and by state was mapped. The annual value ranged from USD 250 to USD 51,000 ha(-1) yr(-1), with a mean of USD 8240 ha(-1) yr(-1) (median = USD 3230 ha(-1) yr(-1)) significantly larger than previous estimates. Coastal wetlands in the US were estimated to currently provide USD 23.2 billion yr(-1) in storm protection services. Coastal wetlands function as valuable, self-maintaining “horizontal levees” for storm protection, and also provide a host of other ecosystem services that vertical levees do not. Their restoration and preservation is an extremely cost-effective strategy for society.

Erwin, P. M., López-Legentil, S., & Schuhmann, P. W. (2010). The pharmaceutical value of marine biodiversity for anti-cancer drug discovery. *Ecological Economics, 70*(2), 445–451.

This study, recognizing the value of the sea as a repository of novel pharmaceuticals, provides the first global estimate of the number, source and market value of undiscovered oncology drugs based on empirical data, industry statistics and conservative modelling assumptions. The model developed predicts 253,120 - 594,232 novel chemicals in marine organisms; 90.4-92.6% of these compounds remain undiscovered. A total of 55 to 214 new anti-cancer drugs are predicted to reach the market sourced primarily from animal phyla (Chordata, Mollusca, Porifera, and Byrozoa) and microbial phyla (Proteobacteria and Cyanobacteria). While no single aspect of extractive marine resource value should be relied upon to account for the opportunity costs of conservation initiatives, the application of

valuation models to ecosystem services further reveals the true, irreversible economic cost of habitat degradation and biodiversity declines.

Farber, S. (1987). The value of coastal wetlands for protection of property against hurricane wind damage. *Journal of Environmental Economics and Management*, *14*(2), 143-151.

The paper has attempted to place a value on wetlands for their role in reducing wind damage to property because of diminished storm intensities. The study estimated a storm wind damage function for the Louisiana gulf coast, where inland distance of a location and wetlands traversed by a hurricane were among the independent was made of the increase in expected wind damage to property from the loss of intervening wetlands. The discounted value of the loss of a one mile strip of wetlands along Louisiana's gulf coast was estimated to be between $1.1 million and $3.7 million in 1980 dollars, using discount rates of 8% and 3%, respectively. The increased cost of property damage amounted to between $7 and $23 per acre. In order to place this in perspective, the market value of Louisiana wetlands is under $200 per acre. This market value is derived primarily from the mineral and hunting rights accompanying the surface area.

Jerath, M. (2012). An Economic Analysis of Carbon Sequestration and Storage Service by Mangrove Forests in Everglades National Park , Florida.

This paper provides a methodological framework for the first estimates of the total carbon storage and its economic valuation in the mangrove forests of Everglades National Park (ENP), Florida. The total carbon storage in the ENP mangroves is estimated to be 7,144 Mg C/ha, much higher than tropical, boreal and temperate forests. The study also estimates the change in the economic value of the carbon stock in ENP mangroves in response to different scenarios of sea level rise.

Johnston, R. J., Grigalunas, T. A., Opaluch, J. J., Mazzotta, M., & Diamantedes, J. (2002). Valuing Estuarine Resource Services Using Economic and Ecological Models: The Peconic Estuary System Study. *Coastal Management*, *30*(1), 47–65.

This article summarizes four integrated economic studies undertaken to contribute to resource preservation and restoration decisions for the Peconic Estuary System of Suffolk County, NY. Completed as part of the National Estuary Program, the studies apply distinct resource valuation methods to a wide range of resource issues. The principal goals of this article are to highlight different methodologies that may be used to assess nonmarket economic values in a coastal management context, and characterize differences in the results that one may expect from each approach. Also emphasized are the potential relationships among values estimated by different nonmarket methodologies. The authors also comment on the implications of these relationships for the interpretation and use of economic value estimates.

Louisiana State University Agricultural Centre (2001). Functions and Values of Wetlands in Louisiana. Louisana Department of Natural Resources Coastal Management Division.

This paper explains the functions and the corresponding values of Louisiana's coastal wetlands and also focuses on its the business and commerce aspects. The values estimated are for storm and flood protection, water qaulity, soil erosion, educational and recreational activities.

Liu, S., Costanza, R., Troy, A., D'Aagostino, J., & Mates, W. (2010). Valuing New Jersey's ecosystem services and natural capital: A spatially explicit benefit transfer approach. *Environmental Management*, *45*(6), 1271–1285.

This paper intends to estimate the value of ecosystem services in the U.S. State of New Jersey using spatially explicit benefit transfer. The aggregated net rent, a conservative underestimate for the total economic value of the state's natural environment, ranged from $11.6 to $19.6 billion/year, conditional on how inclusive the authors were in selecting the primary studies used to calculate the central tendency values to transfer. In addition to calculating the range, mean, and standard deviation for each of 12 ecosystem services for 11 Land Use/Land Cover (LULC) types, a gap analysis of how well ecosystem service values are represented in the literature is also conducted. The paper maps these values by assuming a mean value for each LULC and applies this to spatial data. As to sensitivity analysis, the net present value of New Jersey's natural environment utilizing three different methods of discounting is calculated. These research results provide a useful, albeit imperfect, basis for assessing the value of ecosystem services and natural capital, and their comparison with the value of conventional human and built capitals.

Pendleton, L. H. (2010). The economic and market value of coasts and estuaries: what's at stake? *The economic and market value of coasts and estuaries: what's at stake?*, Restore America's Estuaries, Arlington, VA.

This book examines the economic value of coasts and estuaries with an eye to understanding the economic benefits of protecting and restoring coasts and estuaries in the USA. Some of the critical concepts needed to begin to understand the economic importance of restoration are discussed. Every chapter offers real data and guidance on how to find locally relevant data that may help us understand the value of restoration. Case studies are given that show how economic concepts, data, and analysis can help reveal the economic value of protecting these resources and even improving these values through restoration.

Piehler, M. F., & Smyth, a. R. (2011). Habitat-specific distinctions in estuarine denitrification affect both ecosystem function and services. *Ecosphere*, *2*(1), Article 12.

In this paper, because of the important role nitrogen plays in determining ecosystem function, rates of denitrification (DNF) in aquatic ecosystems of the US were studied. There was a strong correlation between denitrification and sediment oxygen demand (SOD) in all habitats and all seasons, suggesting the potential to utilize SOD to predict DNF. Denitrification efficiency was also higher in the structured habitats than in the flats. Nitrogen removal by these habitats was found to be an important contributor to estuarine ecosystem function. The ecosystem service of DNF in each habitat was evaluated in US dollars using rates from a

regional nutrient-offset market to determine the cost to replace N through management efforts. Habitat-specific values of N removal ranged from approximately three thousand U.S. dollars per acre per year in the submerged aquatic vegetation to approximately four hundred U.S. dollars per acre per year in the subtidal flat.

Pompe, J. J. (1999). Establishing Fees for Beach Protection: Paying for a Public Good. *Coastal Management*, *27*(1), 57–67.

This paper, in an effort to arrive on equitable allocation of the costs of controlling shoreline erosion, provides a method to set fees based on proximity to the beach by using estimates from Seabrook Island, South Carolina. This method is also applicable to other areas that require beach maintenance.

1.5 South Asia

Badola, R., and Hussain, S. A. (2005). Valuing Ecosystem Functions: An Empirical Study on the Storm Protection Function of Bhitarkanika Mangrove Ecosystem, India. *Environmental Conservation*, 32(1), 85–92.

This paper assesses the ecosystem services provided by the mangroves of the Bhitarkanika Conservation Area in Odisha. Three villages were selected and taking the cyclone of 1999 as a reference point the damage avoided due to the Bhitarkanika mangrove ecosystem was estimated. This was estimated by assessing the socio-economic status of the villages, the cyclone damage to houses, livestock, fisheries, trees and other assets owned by the people, and the level and duration of flooding. The three villages were selected based on their geographic location, one protected by mangroves, one unprotected by mangroves, and the third possessing an embankment on its seaward side. These villages were then compared for the damage caused by the cyclone of 1999 based on eleven variables. Attitude surveys were also carried out to for perception assessment of the local people regarding the storm protection function of mangroves and their general attitude towards mangrove forests. The local people were aware of and appreciated the functions performed by the mangrove forests in protecting their lives and property from cyclones, and were willing to cooperate with the forest department in mangrove restoration.

Berg, H., Öhman, M. C., Troëng, S., & Lindén, O. (1998). Environmental economics of coral reef destruction in Sri Lanka. *Ambio*, 627-634.

This study evaluates the ecological services provided by coral reefs and to assess the long-term economic benefits derived from some of the ecosystem functions using available information on coral reefs in Sri Lanka and Southeast Asia. The minimum economic value of coral reefs in Sri Lanka is estimated at USD 140 000-7 500 000 km-2 reef over a 20-yr period. The economic consequences of coral mining were investigated and economic costs (USD 110000-7360000) were found to exceed net benefits (USD 750000 -1670000) by as much as USD 6 610 000 km2 reef when analyzed over 20 years in tourism areas. The highest costs were associated with decreased tourism (USD 2-3 million) and increased erosion (USD

1-4 million). The results have implications for management and show that Sri Lankan legislation banning coral mining in the coastal zone is beneficial to the country's economic development.

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

This paper examines the value of ecosystem services provided by mangroves. It presents a meta-analysis of the economic valuation literature and applies the estimated value function to assess the value of mangroves in Southeast Asia. A database containing 130 value estimates, largely for mangroves in Southeast Asia is constructed. Values are standardised to US$ per hectare per year in 2007 prices. The mean and median values are found to be 4185 and 239 US$/ha/year respectively. The values of mangrove ecosystem services are highly variable across study sites due to, amongst other factors, the bio-physical characteristics of the site and the socio-economic characteristics of the beneficiaries of ecosystem services. Explanatory variables are included in the meta-analysis to account for these influences on estimated mangrove values. A geographic information system (GIS) is used to quantify potentially important spatial variables, including the abundance of mangroves, the population of beneficiaries, and the density of roads in the vicinity of each study site. The meta-analytic value function is used to estimate the change in value of mangrove ecosystem services in Southeast Asia under a baseline scenario of mangrove loss for the period 2000-2050. The estimated foregone annual benefits in 2050 are US$ 2.2 billion, with a prediction interval of US$ 1.6-2.8 billion.

Das, S. (2007). Mangroves - A Natural Defense against Cyclones □: An invest from Orissa , India. Policy Brief No. 24-07. South Asian Network for Development and Environmental Economics.

This study highlights the role that mangrove forests play in protecting coasts by reporting what happened in Orissa's Kendrapada district. The study examines the role of mangroves alongside all the other factors that affected the impact of the storm. It finds that mangroves provide incredibly important protection from storms – if mangrove forests had not been destroyed in the past then over 90 percent of all deaths in Kendrapada due to the cyclone may have been avoided. The benefits from conserving an existing hectare of mangroves are nearly twice the "site" value of land cleared for other development. Thus, there is a strong argument for reestablishing mangroves along the coast of Orissa and other coastal areas threatened by cyclones.

Das, S. (2007). *Storm protection by mangroves in Orissa: an analysis of the 1999 super cyclone*. Working Paper No. 25-07. South Asian Network for Development and Environmental Economics.

This paper assesses the storm protection role afforded by mangroves. It uses data on human casualties, damages to houses and livestock losses suffered in the Kendrapada district of the

State of Orissa during the super cyclone of October 1999. The analysis incorporates meteorological, geo-physical and socio-economic factors to separate out the impact of mangrove vegetation on cyclone damage. The results indicate that the mangroves significantly reduced human death and seemed more effective in saving lives (both human as well as animals) than in reducing damage to static property. While there was significant reduction due to mangroves in damage to residential houses and to big animals like cattle and buffaloes, these results were not robust. If the width of the mangrove forest was 10% more that what it was at the time of the cyclone, human casualties would have been lower by 12.48 %, buffalo loss by 6.6 %, cattle loss by 2.23 % and fully collapsed houses by 2.21%. Factors like land elevation, immovable asset holdings, etc., too, had decisive effects on human casualties in the storm surge affected areas.

Das, S., & Vincent, J. R. (2009). Mangroves protected villages and reduced death toll during Indian super cyclone. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(18), 7357–7360.

This study uses data on several hundred villages to test the impact of mangroves on human deaths during a 1999 super cyclone that struck Orissa, India. It is found that villages with wider mangroves between them and the coast experienced significantly fewer deaths than ones with narrower or no mangroves. This finding is robust to the inclusion of a wide range of other variables to our statistical model, including controls for the historical extent of mangroves. Although mangroves evidently saved fewer lives than an early warning issued by the government, the retention of remaining mangroves in Orissa is economically justified even without considering the many benefits they provide to human society besides storm-protection services.

DebRoy, P., and Jayaraman, R. (2012). Economic Valuation of Mangroves for Assessing the Livelihood of Fisherfolk: A Case Study in India. IIFET 2012 Tanzania Proceedings, 1–11.

This study was carried out in a village named MGR Thittu in the vicinity of the Pichavaram mangroves in the state Tamil Nadu in India. The objectives of the study were to review the current status of mangroves in Tamil Nadu, study the fisherfolk's perceived role of mangroves on their livelihood, estimate the economic value of mangroves as a case study, and suggest policy measures needed for the conservation, protection, management and development of mangroves. The required data were collected randomly from 41 experts and 120 villagers. The most important concern for protecting the mangroves was found to be strengthening of coastline against Tsunami through mangrove plantation. The most important present use of the Pichavaram mangroves was their services through their ecological functions like protection against tsunami, floods and heavy winds; followed by contribution to fishery; and firewood collection.

Emerton, L., and Kekulandala, L. D. C. B. (2003). Assessment of the Economic Value of Muthurajawela Wetland, IUCN, Sri Lanka.

This study aims to generate information, which can contribute to an understanding of the economic benefits of wetland conservation and economic costs of wetland degradation and loss in Muthurajawela. A partial economic valuation of wetland goods and services was carried out as part of the development of the Conservation Management Plan for Muthurajawela Marsh and Negombo Lagoon (CEA 1994). This useful exercise considered the value of Negombo Lagoon as a sink for industrial, domestic and municipal waste disposal; a source of land for housing on inter-tidal sand shoals; a location for lagoon fisheries, coastal shrimp and small pelagic fisheries; and as a an anchorage for marine fishing craft. It also assessed the value of Muthurajawela Marsh for recreation, and for housing land. The current study aims to build on this earlier valuation exercise by looking specifically at the economic values associated with the conservation and sustainable use of Muthurajawela Wetland Sanctuary. A biodiversity assessment was also carried out in Muthurajawela by IUCN, between Novem-ber 1999 and April 2000 (IUCN 2001). The current study aims to complement the biodiversity assessment, and to document ways in which economic concerns can be integrated into biodiversity assessment procedures and used within the context of wetland conservation.

Gunawardena, M., and Rowan, J. S. (2005). Economic Valuation of a Mangrove Ecosystem Threatened by Shrimp Aquaculture in Sri Lanka. *Environmental Management*, 36(4), 535–550.

This study presents an economic assessment for a relatively large shrimp culture development proposed for the Rekawa Lagoon system in the south of Sri Lanka. This also involved an extended cost-benefit analysis of the proposal and an estimate of the "Total Economic Value" (TEV) of a mangrove ecosystem. The analysis revealed that the internal benefits of developing the shrimp farm are higher than the internal costs in the ratio of 1.5:1. However, when the wider environmental impacts are more comprehensively evaluated, the external benefits are much lower than the external costs in a ratio that ranges between 1:6 and 1:11. In areas like Rekawa, where agriculture and fisheries are widely practiced at subsistence levels, shrimp aquaculture developments have disproportionately large impacts on traditional livelihoods and social welfare. Thus, although the analysis retains considerable uncertainties, more explicit costing of the environmental services provided by mangrove ecosystems demonstrates that low intensity, but sustainable, harvesting has far greater long-term value to local stakeholders and the wider community than large shrimp aquaculture developments.

IUCN. (2007). Environmental and Socio-Economic Value of Mangroves in Tsunami Affected Areas Rapid Mangrove Valuation Study, Panama Village in South Eastern Coast of Sri Lanka. IUCN — The World Conservation Union.

This study on the valuation of Mangrove study conducted in Panama, shows the importance of mangroves to the mangrove-associated communities. The study clearly highlights that coastal communities are dependant on a range of mangrove products. Fish, shrimp and fuel wood are the main mangrove products providing cash income and subsistence requirements of the community in the location. Timber and poles, herbs and vegetables and fuel wood are important for their subsistence use. The economic value of mangrove was estimated at Rs.

119,438 (US$ 1,171) per household per year and Rs. 938,502 (US$ 9,201) per ha per year. The study attempted to derive indirect use value in terms of mangrove fishery linkages and the value in terms of coastline protection based on the tsunami impacts on coastal ecosystems and the community.

Khalil, S. (1999). Economic Valuation of the Mangrove Ecosystem Along the Karachi Coastal Areas, The Economic Value of the Environment: Cases from South Asia. Published by IUCN.

This study undertakes the economic valuation of the mangrove ecosytem of the Indus River Delta along the Karachi coastal areas in Pakistan. The expansion of regional industry, agriculture, and population the sustainability of the mangrove ecosystems. This study describes the broad array of goods and services provided by the mangroves, and uses market data to estimate the economic value of a few of them. It then argues for the importance of more thorough mangrove valuation studies as a crucial input into policy decisions which will affect the viability of mangrove ecosystems in the future.

1.6 Sub- Saharan Africa

Emerton, L., and Tessema, Y. (2001). Economic Constraints to the Management of Marine Protected Areas: The Case of Kisite Marine National Park and Mpunguti Marine National Reserve, Kenya. IUCN Eastern Africa Regional Office, Nairobi, Kenya, (May).

This study documents practical lessons learned, and to highlight needs and niches for the use of economic and financial tools for MPA management in the region. The case study was carried out as part of the Pilot Project on Partnerships for the Management of Kisite Marine National Park and Mpunguti Marine National Reserve Complex, implemented by the Kenya Wildlife Service and technical assistance from IUCN - The World Conservation Union. The overall goal is to contribute towards ecologically and economically sustained marine and coastal biodiversity conservation through the integration of community livelihoods, development of coastal tourism and marine protected areas.

Turpie, J., Smith, B., Emerton, L., & Barnes, J. (1999). Economic value of the Zambezi Basin Wetlands. IUCN Zambezi Basin Wetlands Conservation and Resource Utilization Project.

This resource economics study forms part of the Zambezi Basin Wetlands Resource Conservation and Utilisation Project (ZBWCRUP) which was initiated by the IUCN. The total economic contribution of fisheries is related to overall wetland size. Fisheries in the different wetland areas contribute between US$0.7 and US$8.2 million to national economies annually. Harvest of wild animal resources was generally found to be low, with survey respondents usually referring to small animals such as birds and rodents. These resources are severely depleted in all of the wetlands. Values were somewhat higher in Caprivi, where game animals are still replenished by the wetlands' connection with the Chobe National Park.

Turpie, J. (2000). The Use and Value of Natural Resources of the Rufiji Floodplain and Delta, Tanzania. Unpublished Report to IUCN (EARO), November.

This paper undertakes valuation of the use of natural resources of the Rufiji floodplain and delta in Tanzania. In order to estimate the direct consumptive use value of natural resources, a survey was carried out in nine villages across these three ecoregions. A total of 128 households were surveyed. Value estimates were assigned to different broad habitat types in the study area, using a GIS coverage of the study area to estimate the area of different habitat types within each of the ecoregions. The direct use values of the broad habitat types are roughly $192/ha/y for estuaries and inshore waters, $42/ha/y for freshwater systems, $17/ha/y for mangroves, $14/ha/y for bushlands, woodlands and forests, and $2/ha/y for floodplain grasslands. In comparison, cultivated lands are worth $63/ha/y. The annual flooding of the Rufiji River probably contributes about $2.75 million to the agricultural value of the floodplain. The delta provides a nursery function for the offshore commercial prawn fishery, worth some $4.5 million. Carbon sequestration values may be as high as $230 million. Taking these values into account, the value of natural habitats can be seen to be substantially higher, ranging from $17/ha for floodplain grasslands, but with all other habitats having higher values than the $63/ha for cultivated lands. Indeed, the value of grasslands would also undoubtedly be higher if the water purification function could be estimated and if their role in fishery productivity was taken into account. However, the above values are only part of the total economic value of natural habitats and All of these values require further investigation.

Turpie, J. K. (2003). The Existence Value of Biodiversity in South Africa: How Interest, Experience, Knowledge, Income and Perceived Level of Threat Influence Local Willingness to Pay. *Ecological Economics*, 46(2), 199–216.

This study investigates the public interest, experience and knowledge of biodiversity and uses contingent valuation methods to estimate its existence value, with emphasis on the internationally significant fynbos biome in the Western Cape, South Africa. More than half of respondents classified themselves as actively or passionately interested in nature, and a high proportion had recently visited major nature reserves. Interest was correlated with knowledge, and both were positively correlated with willingness to pay (WTP) for biodiversity conservation, though WTP was constrained by income level.

1.7 Global/ Multi-Regions

Barbier, E. B., Hacker, S. D., Kennedy, C. J., Koch, E. W., Stier, A. C., & Silliman, B. R. (2011). The value of estuarine and coastal ecosystem services. *Ecological Monographs*, *81*(2), 169–193.

This paper reviews the main ecological services across a variety of Estuarine and coastal ecosystems (ECEs), including marshes, mangroves, nearshore coral reefs, seagrass beds, and sand beaches and dunes. Some estimates of the key economic values arising from these

services have been indicated and how the natural variability of ECEs impacts their benefits, the synergistic relationships of ECEs across seascapes, and management implications are discussed. In conclusion, an action plan is suggested for protecting and/or enhancing the immediate and longer-term values of ECE services. Because the connectivity of ECEs across land–sea gradients also influences the provision of certain ecosystem services, management of the entire seascape will be necessary to preserve such synergistic effects. Other key elements of an action plan include further ecological and economic collaborative research on valuing ECE services, improving institutional and legal frameworks for management, controlling and regulating destructive economic activities, and developing ecological restoration options.

Barbier, E. B. (2012). Progress and challenges in valuing coastal and marine ecosystem services. *Review of Environmental Economics and Policy*, *6*(1), 1–19.

This article examines how environmental and resource economics has contributed to our knowledge of coastal and marine ecosystems' (CMEs) services and discusses progress as well as challenges in valuing these services. The article highlights case studies in which the economic valuation of key CME services has influenced policy decisions concerning the management of CMEs. Two key features of CME benefits are also examined. First, the natural spatial variability in these systems can influence the economic value of CME services. Second, because they occur at the interface between watersheds, the coast, and open water, CMEs can produce cumulative and synergistic benefits across the entire seascape that are much more significant and unique than the services provided by any single ecosystem.

Brander, L. M., Van Beukering, P., & Cesar, H. S. (2007). The recreational value of coral reefs: a meta-analysis. *Ecological Economics*, *63*(1), 209-218.

This study conducts a meta-analysis of substantial literature on economic valuation of coral reefs. 166 coral reef valuation studies were collected, 52 of which provided sufficient information for a statistical meta-analysis, yielding 100 separate value observations in total. The meta-regression results reveal a number of important factors in explaining variation in coral reef recreational values, notably the area of dive sites and the number of visitors. Different valuation methods are shown to produce widely different values, with the contingent valuation method producing significantly lower value estimates. It is concluded thate there is a need for further high-quality valuation research on coral reefs.

Brander, L., Brouwer, R., & Wagtendonk, A. (2013). Economic valuation of regulating services provided by wetlands in agricultural landscapes: A meta-analysis. *Ecological Engineering*, *56*, 89–96.

This paper presents a meta-analysis of the economic valuation literature on ecosystem services provided by wetlands in agricultural landscapes. Focus is given on the value of three regulating services, namely flood control, water supply and nutrient recycling. A database is constructed containing 66 value estimates, mainly for wetlands in the US and Europe but also a substantial number in developing countries. Values are standardised to USD per hectare per year. The mean (median) values are found to be 6923 (427). USD/ha/yr for flood control;

3389 (57). USD/ha/yr for water supply; and 5788 (243). USD/ha/yr for nutrient recycling. The values of these services are highly variable across individual wetland sites due to, amongst other factors, differences in wetland type, size, the scarcity or abundance of other wetlands in the surrounding landscape, and the socio-economic characteristics of the beneficiaries of these services. GIS is used to quantify potentially important spatial variables. The meta-regression is used to produce a value function for wetland regulating services, which can be used to transfer values to other wetland sites while controlling for site and context specific characteristics.

Brander, L. M., Florax, R. J., & Vermaat, J. E. (2006). The empirics of wetland valuation: a comprehensive summary and a meta-analysis of the literature. *Environmental and Resource Economics*, *33*(2), 223-250.

This compilation collects over 190 wetland valuation studies, providing 215 value observations, in order to present a more comprehensive meta-analysis of the valuation literature that includes tropical wetlands (e.g., mangroves), estimates from diverse valuation methodologies, and a broader range of wetland functions (e.g., biodiversity value). It is found that socio-economics variables, such as income and population density, that are often omitted from such analyses are important in explaining wetland value. The prospects for using this analysis for out of sample value transfer with average transfer errors of 74%, with just under one-fifth of the transfers showing errors of 10% or less are also assessed. This overall performance is, however, dominated to a considerable extent by transfer to small sites. The performance of value transfer for medium to large wetlands on average shows transfer errors smaller than 30%.

Conservation International, Coastal Ocean Values Center, World Resource Institute, NOAA, & International Coral Reef Initiative. (2008). Economic Values of Coral Reefs, Mangroves, and Seagrasses: A Global Complilation 2008. *Smithsonian*, 35.

This paper estimates the values for coral reefs and surrounding ecosystems at global, regional and site-specific levels. The ecosystems services valued include tourism and recreation, fisheries, coastal protection, biodiversity and carbon sequestration. The paper also presents values for the costs of degradation or loss of ecosystem services.

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'neill, R.V., Paruelo, J. and Raskin, R.G., (1998). The value of the world's ecosystem services and natural capital. *Ecological economics*, *1*(25), pp.3-15.

This study estimates the economic value of seventeen ecosystem services for sixteen biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$ 16–54 trillion (10^{12}) per year, with an average of US$ 33 trillion per year. Global gross national product total is around US$18 trillion per year.

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S. J., Kubiszewski, I., Farber, S. and Turner, R.K (2014). Changes in the global value of ecosystem services. *Global Environmental Change*, *26*(1), 152–158.

This paper provides an updated estimate of the global value of ecosystem services estimated in 1997 to average $33. trillion/yr in 1995 $US ($46. trillion/yr in 2007 $US). The updated estimate is based on updated unit ecosystem service values and land use change estimates between 1997 and 2011. Some of the critiques of the 1997 paper are also addressed by the authors. Using the same methods as in the 1997 paper but with updated data, the estimate for the total global ecosystem services in 2011 is $125. trillion/yr (assuming updated unit values and changes to biome areas) and $145. trillion/yr (assuming only unit values changed), both in 2007 $US. The loss of eco-services from 1997 to 2011 due to land use change is estimated at $4.3-20.2. trillion/yr, depending on which unit values are used. The underlying data and models can be applied at multiple scales to assess changes resulting from various scenarios and policies. It is emphasized that valuation of eco-services (in whatever units) is not the same as commodification or privatization. Many eco-services are best considered public goods or common pool resources, so conventional markets are often not the best institutional frameworks to manage them. However, these services must be (and are being) valued, and new common asset institutions are needed to better take these values into account.

Defra (UK). (2007). An Introductory Guide to Valuing Ecosystem Services. Department for Environment Food and Rural Affairs.

This Introductory Guide looks at how the framework for the valuation of the natural environment could be improved by offering a comprehensive and systematic means to ensuring that ecosystems and the services they provide are taken into account in policy appraisal. It builds on traditional valuation approaches by explicitly considering the environment as a whole bringing together land, water, air, soil and biodiversity and recognising that their linkages provide a wide variety of services and benefits that are not specific to any one part. The approach stresses that changing any one part of our environment can have consequences, both positive and negative, and often unintended for the ecosystem as a whole. This Guide is a first step towards Defra's aim to embed impacts on the natural environment in decision-making. It is purposely introductory, recognising that further testing and development is needed to operationalise this approach in policy appraisal across government.

De Groot, R. S. (1992). *Functions of Nature: Evaluation of Nature in Environmental Planning, Management and Decision Making*. Wolters-Noordhoff BV.

This book discusses evaluation techniques and ecosystem services that would help guide the readers in environmental planning, management and decision making regarding ecosystem services. Concepts, methods and arguments on environmental assessment and ecological

evaluation, functions of natural environment, socio-economic evaluation, functions and values of natural ecosystems along with case studies and tools for environmental planning, management and decision making are discussed.

De Groot, R., Brander, L., Van Der Ploeg, S., Costanza, R., Bernard, F., Braat, L., Christie, M., Crossman, N., Ghermandi, A., Hein, L. and Hussain, S. (2012). Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem Services*, *1*(1), 50–61.

This paper gives an overview of the value of ecosystem services of 10 main biomes expressed in monetary units. In total, over 320 publications were screened covering over 300 case study locations. Approximately 1350 value estimates were coded and stored in a searchable Ecosystem Service Value Database (ESVD). A selection of 665 value estimates was used for the analysis. Acknowledging the uncertainties and contextual nature of any valuation, the analysis shows that the total value of ecosystem services is considerable and ranges between 490 int$/year for the total bundle of ecosystem services that can potentially be provided by an "average" hectare of open oceans to almost 350,000 int$/year for the potential services of an "average" hectare of coral reefs. The results show that most of this value is outside the market and best considered as non-tradable public benefits. The continued over-exploitation of ecosystems thus comes at the expense of the livelihood of the poor and future generations.

Ghermandi, A., & Nunes, P. A. (2013). A global map of coastal recreation values: Results from a spatially explicit meta-analysis. *Ecological economics*, *86*, 1-15.

This paper examines the welfare dimension of the recreational services of coastal ecosystems. First, a global database of primary valuation studies that focus on recreational benefits of coastal ecosystems is constructed. Second, the profile of each of the 253 individual observations is enriched with characteristics of the built coastal environment (accessibility, anthropogenic pressure, human development level), natural coastal environment (presence of protected area, ecosystem type, marine biodiversity), geo-climatic factors (temperature, precipitation), and sociopolitical context. Further, a meta-analytical framework is proposed that is built upon a Geographic Information System (GIS) and allows for the exploration of the spatial dimension of the valued ecosystems, including the role of spatial heterogeneity of the selected meta-regression variables as well as the spatial profile of the transferred values. The empirical outcome results in the first global map of the values of coastal recreation, which may play a crucial role in identifying and ranking coastal area conservation priorities from a socio-economic perspective.

Liu, S., & Stern, D. I. (2008). A Meta-Analysis of Contingent Valuation Studies in Coastal and Near-Shore Marine Ecosystems, MPRA Paper No. 11608, CSIRO.

This study collects 39 contingent valuation papers with 120 observations to conduct the first meta-analysis of the ecosystem service values provided by the coastal and nearshore marine systems. The results show that over ¾ of the variation in Willingness to Pay (WTP) for coastal ecosystem services could be explained by variables in commodity, methodology, and

study quality. The meta-regression model was also used to predict out-of-sample WTPs. It can be argued that such meta-analyses can provide useful guidance regarding at least the general magnitudes of welfare effects.

Mukherjee, N., Sutherland, W. J., Dicks, L., Hugé, J., Koedam, N., & Dahdouh-Guebas, F. (2014). Ecosystem Service Valuations of Mangrove Ecosystems to Inform Decision Making and Future Valuation Exercises. *PLoS ONE*, *9*(9), e107706.

This study conducts an ecosystem services valuation study for mangroves ecosystems, the results of which can be used to inform governance and management of mangroves. An expert-based participatory approach (the Dephi technique) was used to identify, categorize and rank the various ecosystem services provided by mangrove ecosystems at a global scale. A total of 16 ecosystem services were idenstified, six of which are not adequately represented in the literature. There was no significant correlation between the expert based valuation (the Delphi technique) and the economic valuation, indicating that the scope of valuation of ecosystem services needs to be broadened. Acknowledging this diversity in different valuation approaches, and developing methodological frameworks that foster the pluralism of values in ecosystem services research, are crucial for maintaining the credibility of ecosystem services valuation.

Pearce, D., and Moran, D. (1994). The Economic Value of Biodiversity, IUCN — The World Conservation Union.

This study is on the economic value of biodiversity. The study suggests that if the world's economies are rationally organized, biodiversity must have less economic value than the economic activitis giving rise to its loss. It is common knowledge that biological resources do have significant economic value. We also know that many of the destructive activities themselves have very low economic value; therefore something is wrong with the way actual economic decisions are made — for some reason they fail to `capture' the economic values that can be identified. These `economic failures' lie at the heart of any explanation for the loss of biological diversity. If we can address them, there is a chance of reducing biodiversity loss.

Rao, N. S., Ghermandi, A., Portela, R., & Wang, X. (2015). Global values of coastal ecosystem services: A spatial economic analysis of shoreline protection values. *Ecosystem Services*, *11*, 95–105.

This paper attempts a global study to estimate the ecosystem service value of specific coastal ecosystems is developed. Specific variables are identified and used to develop a global multivariate regression function that supports the identification of important drivers of the value of ecosystem service of coastal protection around the world, and the Caribbean is examined in detail. Results of the meta-analytic regression show that variables significantly affecting the ecosystem service value included size, level of development, storm frequency, valuation method and gross domestic product per capita. A benefit transfer function is also generated to extrapolate values to other sites around the world where coastal wetlands, mangrove and coral reefs exist. This function is used to derive a global map of the value of a

set of coastal ecosystem services worldwide. The Caribbean region is discussed as a case study in this global analysis.

Rönnbäck, P. (1999). The ecological basis for the economic value of mangrove forests in seafood production. *Ecological Economics*, *29(2)*, 235–252.

This article identifies and synthesizes ecological and biophysical links of mangroves that sustain capture fisheries and aquaculture production. Fish, crustacean and mollusc species associated with mangroves are presented and the ecology of their direct use of this system is reviewed. Through a coastal seascape perspective, biophysical interactions among mangroves, seagrass beds and coral reefs are illustrated. The life-support functions of mangrove ecosystems also set the framework for sustainable aquaculture in these environments. Estimates of the annual market value of capture fisheries supported by mangroves ranges from US$750 to 16 750 per hect
support value of mangroves. The value of mangroves in seafood production would further increase by additional research on subsistence fisheries, biophysical support to other ecosystems, and the mechanisms which sustain aquaculture production.

Russi D., ten Brink P., Farmer A., Badura T., Coates D., Förster J., Kumar R. and Davidson N. (2013) The Economics of Ecosystems and Biodiversity for Water and Wetlands. IEEP, London and Brussels; Ramsar Secretariat, Gland.

TEEB for Water and Wetlands builds on the TEEB approach to generate a better understanding of the ecosystem service values of water and wetlands and encourage improved decision making and business commitment for their conservation, investment and wise use. The primary objective of the report is to help identify major gaps and inconsistencies in current knowledge of the economics of water and wetlands, so as to inform agenda-setting for further work on the economics of water and wetlands.

Talbot, F., and Wilkinson, C. (2001). Coral Reefs, Mangroves and Seagrasses: A Sourcebook for Managers. Australian Institute of Marine Science.

This book is written for resource managers and educators. Its goal is to provide information and practical examples to help prevent further damage to coral reefs and other tropical coastal ecosystems. Real life situations are cited to draw conclusions and give practical advice on the management of coral reefs, mangrove forests and seagrass beds. Examples have been outlined where there have been real successes and failures, and further methods are provided for improved management of coastal resources, based on these case studies. The information in this book is drawn from the best available expertise of scientists and marine resource managers. The aim is to highlight the dominant issues and suggest achievable solutions to what are sometimes complex situations.

Troeng, S., & Drews, C. (2004). Money talks: economic aspects of marine turtle use and conservation. WWF- International

This paper estimates gross revenue from consumptive use of marine turtle meat, eggs, shell, leather and bone at nine case study sites in developing countries. Gross revenue from consumptive use range from US$ 158 to US$ 1,701,328 yr-1 per case study with an average of US$ 581,815 yr-1. Direct beneficiaries from consumptive use vary from a handful to several hundred. The case studies suggest that promotion of consumptive uses of endangered marine turtles is not precautionary, either from an ecological or an economic perspective. Current global marine turtle conservation expenditure is estimated at a minimum of US$ 20 million per year. In order to maintain the intrinsic values of marine turtles, their roles in ecosystem functioning and in providing benefits to people, their populations need to be restored worldwide to healthy levels. Failure to reverse marine turtle decline would imply a replacement cost for nesting females through captive breeding estimated at US$ 245.9-US$ 263.3 million for green and US$ 2.5 billion for leatherback turtles. The cost of rearing turtles in captivity suggests that conservation of marine turtles in the wild is less expensive.

Turner, R. K., Paavola, J., Cooper, P., Farber, S., Jessamy, V., and Georgiou, S. (2003). Valuing Nature: Lessons Learned and Future Research Directions. *Ecological Economics*, 46(3), 493–510.

This paper critically reviews the literature on environmental valuation of ecosystem services across the range of global biomes. The main objective of this review is to assess the policy relevance of the information encompassed by the wide range of valuation studies that have been undertaken so far. Published and other studies now cover most ecosystems, with aquatic and marine contexts attracting the least attention. There is also a predominance of single function valuation studies. Studies valuing multiple functions and uses, and studies which seek to capture the “before and after” states as environmental changes take place, are rare. n general, valuation data provide prima facie support for the hypothesis that net ecosystem service value diminishes with biodiversity and ecosystem loss.

Turner, R. K., van den Bergh, J. C. J. M., Soderqvist, T., Barendregt, A., van der Straaten, J., Maltby, E., and van Ierland, E. C. (2000). Ecological-Economic Analysis of Wetlands: Scientific Integration for Management and Policy. *Ecological Economics*, 35(1), 7–23.

This study, through an integrated wetland research framework, suggests that a combination of economic valuation, integrated modelling, stakeholder analysis, and multi-criteria evaluation can provide complementary insights into sustainable and welfare-optimising wetland management and policy. Subsequently, each of the various components of such integrated wetland research is reviewed and related to wetland management policy.

Waycott, M., Duarte, C.M., Carruthers, T.J., Orth, R.J., Dennison, W.C., Olyarnik, S., Calladine, A., Fourqurean, J.W., Heck, K.L., Hughes, A.R. and Kendrick, G.A. (2009). Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proceedings of the National Academy of Sciences, 106(30), pp.12377-12381.

This paper studies the impact of human activities on coastal ecosystems and services around the globe. A comprehensive global assessment of 215 studies found that seagrasses have been disappearing at a rate of 110 km(2) yr(-1) since 1980 and that 29% of the known areal extent has disappeared since seagrass areas were initially recorded in 1879. Furthermore, rates of decline have accelerated from a median of 0.9% yr(-1) before 1940 to 7% yr(-1) since 1990. Seagrass loss rates are comparable to those reported for mangroves, coral reefs, and tropical rainforests and place seagrass meadows among the most threatened ecosystems on earth.