Valuation of Ecosystem Services in Coastal Ecosystems: Asian and European perspectives.

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Abstract:

The coastal ecosystem is essential to life on our planet and supports the livelihood of people living and depending on coastal resources. The abundance of good quality coastal resources is fundamental to all marine biological processes and supports living resources. Moreover it is essential for the maintenance of biodiversity and ecosystems, in addition to primary and secondary production functions that support human needs. Valuation studies of coastal resources will considerably increase our knowledge of the value of ecosystems. Their usefulness has often been undermined due to undervaluation, the main reason for coastal resources destruction. Despite a global consensus on the need to implement stakeholder management approaches and on Millennium Development Goals for food security, poverty reduction and preservation of ecosystems, the reality in most countries is a competition between different groups and sectors for access to coastal ecosystem services. The real value of wetlands plays a major role in this predicament. A variety of innovative methods of economics are usually applied in the valuation of cultural and provisioning services in coastal ecosystem under the concept of total value. The basic premise underlying all these economic valuation techniques is the individual's willingness to pay (WTP) or willingness to accept (WTA). The contingent valuation method (CVM) uses a direct stated preference approach to valuing an environment good or service in that it asks people through surveys or experiments what they are WTP for the good or WTA for the loss of the good. A demand curve can be traced using the bid values estimated in a CVM study which is particularly attractive because it can estimate values where market do not exist or where market substitutes cannot be found. Choice experiment (CE) is becoming an increasingly popular stated preference technique in valuing coastal resources. CE is considered to be both an evolution of and an alternative to CVM and both methods use stated preference approaches and both are usually based on random utility theory. Two studies in Europe and Asia using CVM and CE approaches for valuing cultural and provisioning ecosystem services are highlighted in this paper. There is an urgent need for research to determine the status of regulating services and how the value can actually be captured and incorporated in decision making process in ecosystem management.

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Introduction

Oceans cover approximately 71% of the surface of the earth and supports 44% of the human population living within 93 miles, as of 2007. Therefore, the coastal ecosystem is essential to life on our planet as well as to support the livelihood of people living and dependent on the coastal resources. The abundance of coastal resources of good quality is fundamental to all marine biological processes, for maintenance of biodiversity and ecosystems and for primary and secondary production functions that supports human needs. Competition for limited resources has intensified with human population growth in coastal regions and the diversion of wetlands for economic activities has been experienced globally. It is equally important to underline that such threatened ecosystems can no longer provide their biological functions and regulate services that sustain coastal economic production and livelihoods. Scientists recognise four categories of ecosystem services in coastal regions: *provisioning services* such as food, mangrove, fibre, and water; *regulating services* such as the regulation of climate, coastal erosion, coral bleaching, pollution and disease; *cultural services* including recreational, spiritual and other non-material benefits; and *supporting services* such as nutrient cycling and photosynthesis. There is a global consensus on the need to implement stakeholder management approaches for food security, poverty reduction and the preservation of ecosystems using coastal resources. The reality in most countries is a competition between different groups and sectors for access to coastal resources, other natural resources and water. This is very crucial in coastal zones mainly due to the migration of people from other regions to coastal cities. There is an urgent need, therefore, to reconcile demands for maintaining coastal ecosystem functions and for producing food and services to the people. Finding the right balance is particularly important in developing countries, where the coastal environment is often the principle growth centre of the region. The right balance is difficult to maintain in coastal cities and as a result, the alleviation of poverty and reduction of hunger rarely arises.

Marine ecosystem services include the provision of seafood, filtration of nutrients coming from the land, recycling of nutrients, control of pests and pathogens, climate regulation, protection of coasts from erosion, places for recreation or inspiration or cultural heritage to name a few. Ecosystem services are nearly always undervalued. Among the categories of ecosystem services, provisioning and cultural services are easy to understand and relatively easy to value. Regulating and supporting services are difficult to understand, hence becoming undervalued. Some coastal ecosystem goods such as water, fish and shellfish have significant economic value as they are exchanged in market for a determined price. However, most other essential services, especially regulating services are neither appreciated nor commonly assigned economic worth. Services such as the protection of shorelines from erosion, nutrient recycling, climate regulation, cultural heritage, control of disease and pests and spiritual benefits are at risk because they are undervalued. These goods are not exchanged in a market place and in present economic systems attach no monetary values to these services. At present ecosystem management typically ignore the value of these goods in a decision on whether to conserve these resources or convert into development and many are subsequently at risk (Wattage & Mardle, 2005).

Rationale for valuing the regulating services of coastal ecosystems and issues

Ecosystems provide a wide variety of useful services that help human welfare. These services are the result of the existence of biotic and abiotic resources and their complex interactions. It is a complex mixture of plant, animal, and other microscopic life and its interactions with the non-living environment. The complexity of the ecosystem deteriorates as a result of the interaction of human activities. The natural ecosystems such as forest ecosystem, freshwater ecosystem, marine ecosystem and coastal ecosystem interacts with cultivated ecosystem. The functions of ecosystems which are of bio-geophysical in nature result in the flow of various services and benefits for humans and their society. These benefits include provisioning services such as food and water, regulating services such as flood and disease control, cultural services such as spiritual, recreational and cultural benefits and supporting services such as nutrient cycling that maintain the conditions for life on earth. The Millennium Ecosystem Assessment of the UN predicted that 60% of the ecosystem services linked to biodiversity are being exploited in an unsustainable manner or are being degraded. The damage to regulating services is catastrophic and much of the ensuing loss in biodiversity is the consequence of human-induced pressures. The coastal regions of the ecosystems that connect terrestrial and coastal ecosystems are of particular relevance to human activities.

Coastal ecosystems are areas where land and water join to create an environment with a distinct structure, diversity and flow of energy, providing a wide array of goods and services to humankind. They include mangrove swamps, salt marshes, wetlands, estuaries and bays that are home to many different types of plants and animals. They are very sensitive to changes in the environment and there is concern that some areas are now struggling to maintain their diversity due to human activity. In addition, natural phenomenon have been responsible for a significant amount of damage to coastal ecosystems, displacing marine and other wildlife, draining food supplies, and disrupting the balance of coastal ecosystem.

The rationale for valuing regulating systems in coastal regions is justified because marine, terrestrial, and coastal ecosystems all provide ecosystems that are essential to human survival. This ecosystem generates what is called ecosystem functions, also known as ecological production function. The ecological production function depends upon the initial condition of the ecosystems. The combined human-made and natural force usually causes a shift in the flow of these services. Marginal changes to the ecological production function would indicate the status of the resources. Using economic valuation method it is possible to assign values for the resources to capture the output of ecological production function. Policy makers can use these values to design and better manage the ecosystems to provide human well being.

In addition to valuing coastal ecosystem based on what it provides for human survival, values can also be used in estimating the dame to the resource base. The most significant issue facing coastal areas is runoff from industrial, agricultural and municipal areas, sometimes stemming far from the coastal area causing the externality. The runoff related pollution can result in higher nutrient and/or pollutant levels in coastal waters, causing algae blooms that can be dangerous to both humans and marine life. Fish resources will be affected by this impact which has devastating effect for the people dependent upon fish. Potential contamination of coastal and ocean waters by run-off waters further damages and diminishes existing fish resources. Existing fishermen attempt to maximise their catch through the utilisation of destructive fishing practices and overfishing, further threatening both coastal fish populations and their habitats. Aquaculture in coastal areas can reduce pressure on some native stocks, however the effluent from fish farms can contaminate the surrounding water, introducing a different environmental problem. If farm fish escape they can compete with native fish, potentially becoming an invasive species. In order to regulate a proper management in the coastal areas these resources need to be valued and accounted for in management. The damage caused by human induced activities can also be quantified if the total value of the resource is known and obvious to the management and the general public.

The underlying issues in valuing regulating services of coastal ecosystems are very complex. The process of regulating services is difficult to understand, making quantifying benefits complicated. Coastal ecosystems, such as mangrove and marsh, are widely believed to provide a variety of hydrological services, including water quality improvement, as well as reducing erosion and sediments, providing the link between the terrestrial and marine ecosystem. This ecosystem plays a significant role in replenishing various fish populations and providing breeding grounds for fish species for the coastal and lagoon fish industry. Food for marine micro organisms are provided by the nutrients supplied to the lagoon as detritus from the mangrove ecosystems, which is carried into the coastal waters by the tidal currents. This is the beginning of the marine food chain and also provides services such as refuge and nursery grounds for juvenile fish, shrimps, crabs and molluscs. During the Indian Ocean Tsunami mangroves acted as barriers to reduce the force of the waves in some locations (IUCN, 2008). It is difficult to fully elucidate and value the regulatory service of mangroves as a prime nesting ground and migratory sites for bird species.

Innovative methods of economics usually applied in valuation of coastal resources

The need for plans to address issues such as the protection and sustainable use of coastal ecosystems is a major concern of international organizations, including the Food and Agricultural organisation (FAO), International Union for Conservation of Nature (IUCN), the UN Commission on Sustainable Development (CSD), Ramsar Convention of Wetlands and the Convention on Biological Diversity. Sustainable use of coastal resources is governed by the value of coastal resources and it was a key theme of the discussion of international organisations. For example, water use for food production in agriculture and fisheries and water in ecosystems (nature benefits) are important water functions that provide a major contribution to economic growth and poverty eradication but are not particularly allocated the right price. As such resources tend to be misused or over used. In allocating rights to the use of water, judgements must be based on the economic, social, environmental and cultural values and not the face value of water solely. The need of water for food production is evident and the contribution can be measured in monetary terms. It is less self-evident to enhance food security through more efficient mobilisation and use of water, making its value less translucent. Water allocation for agriculture is very apparent and the water value going into agriculture is measurable. However, contribution of water ensuring the integrity of ecosystems is less visible and the valuation of the contribution is more difficult to estimate. The critical importance of proper management of water, for food and ecosystems has not been addressed sufficiently, due to the absence of total economic value.

The concept of 'economic value' defined in the standard economic theory is the measurement of changes in personal well-being. The theory has been further extended to measure changes in the prices and quantities of marketed goods as well as public and other non-market goods and services. A key concept used in these analyses is the economic surplus, which consists of consumer's surplus and producer's surplus. Consumer surplus is the difference between the maximum amount that a consumer would pay and the amount that they actually pay, while producer's surplus refers to the difference between the revenues received and the cost of production for a commodity. Conceptually, the total economic value (TEV) of a resource consists of its use value (UV) and non-use value (NUV) (or passive-use value). There are several definitions for the TEV of an environmental resource used by several authors. Since Krutilla (1965), the TEV approach has generally been adopted in estimating the value of environmental resources or ecosystems. Environmental economists employ the concept of TEV that focuses on monetising a set of human preferences towards a natural system. Use values may be broken down further into direct use values (DUV), the indirect use values (IUV) and the option values (OV). Direct use values of the coastal wetlands include both its consumptive uses such as fish, shellfish and fuel wood, as well as non-consumptive uses of wetland "services" such as recreation, ecotourism, bird watching, *in-situ* research and education and navigation. It is rather straightforward to derive values because there is an established market for provisioning services of ecosystem. Various functional values of wetland ecosystems are an example of important indirect use values. Their values derive from supporting or protecting economic activities such as fisheries via nursery/habitat functions, waste treatment, flood control, storm protection and so on. Values for non-consumptive services such as recreation and ecotourism can be assessed using a revealed preference type travel cost method (TCM). Part of the option value could also be a potential use value. Therefore, one needs to be careful not to double-count both the value of indirect supporting functions and the value of the resulting direct use. In the economic literature, the option value is a difference between *ex ante* and *ex post* valuation due to the uncertainty about his or her future use for a resource and/or its availability as a wetland ecosystem in the future. Although there is a dispute on categorisation of option value, it is widely included in one of non-use values in a number of previous studies, for instance under the collective term of 'preservation values' (Walsh *et al.*, 1985). In particular, US Federal Court's definition of passive-use values includes 'option value' (Carson *et al.*, 1999). Quasi-option value is potential benefit occurring from delaying exploitation and conversion of the wetland today (Barbier, 1994). Part of indirect use values comes under the regulating services such as flood control, carbon storage and water catchment functions of coastal areas. For example, estuaries provide regulating services because they absorb the forms of storm in coastal areas and regulate changes in air and water temperature. These functions are difficult to measure and value mainly because of a lack of an established price. One possible method is estimating the foregone or lost values of goods as a result of damaging the regulating services (flood control). These services are developing over time, as such they can be estimated using dynamic optimization approaches using the price of foregone goods.

Non-use values are composed largely of bequest values (BV) and existence values (EV). Bequest values are the values that people derive from knowing that others will be able to benefit from the resource in the future. Existence values are the perceived values of the environmental asset unrelated either to current or future use, i.e., simply because it exists. Even though there are no conclusive terms associated with non-use values, in general the terms of passive-use value (Arrow et al., 1993; Carson et al., 1999) and preservation value encompass option value as well as non-use values, including the existence value and bequest value. Non-use values in coastal ecosystems are the coastal nature preservation value reflecting the wish to allow descendents to benefit (bequest value) and preserving coastal biodiversity value attached to the fact that a given good exists (existence value). These cultural services values of coastal ecosystems are very difficult to estimate; recently total value estimation has been used for this purpose. A variety of innovative methods of economics are usually applied in valuation of ecosystem services under the concept of total value. The basic premise underlying all these economic valuation techniques is an individual's willingness to pay (WTP) or willingness to accept (WTA). For an environmental resource under study we estimate the area under the compensated or Hicksian demand curve to quantify the economic values.

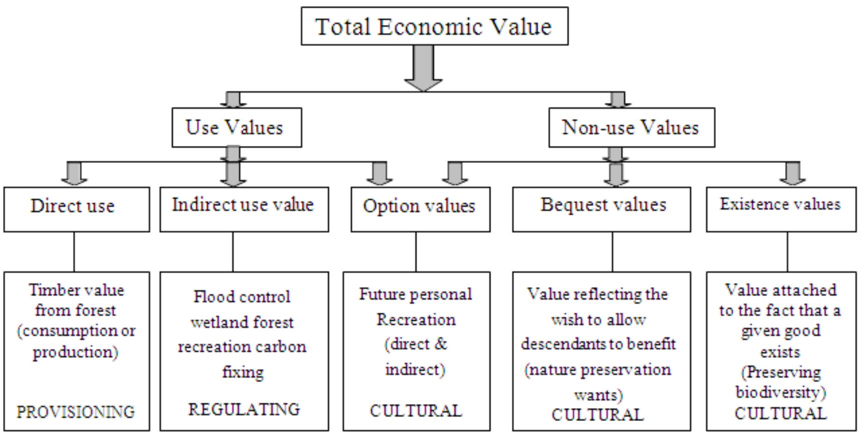

Figure 1: Breakdown of total economic value

The contingent valuation method (CVM) uses a direct stated preference approach to valuing environmental goods or services, in that it asks people through surveys or experiments what their WTP for the goods or WTA is for the loss of the goods. A demand curve can be traced using the bid values estimated in a CVM study. For these reasons, CVM is widely used to measure existence values, option values, indirect use values and non-use values. Choice experiment (CE) is becoming an increasingly popular stated preference technique in valuing coastal resources. CE is considered to be both an evolution of and an alternative to CVM.

According to Adamowicz and Boxall (2001) choice experiments can be regarded as a variant of CVM because both methods use stated preference approaches and both are usually based on random utility theory. CE uses attributes and levels under study in an experimental design for the construction of response surfaces from the data, which are major variants from CVM.

CE is based on the foundation of Lancastrian consumer theory and random utility theory. Further, psychological theories on information processing in judgement and decision-making have also played a fundamental role. Lancastrian consumer theory suggests that utilities for goods can be decomposed into separate utilities for their attributes (Lancaster 1966) which is a key characteristic of CE. Random utility theory explicitly models the choice among substitute alternatives for a given occasion considering constraints used in the model. The choice being modelled as a function of the characteristics of the substitute alternatives. The random component takes into account, inter alia, the possibility that the analyst may have omitted variables or committed measurement errors, or that the consumer may have been inattentive during the choice process (Adamowicz et al 1998b). Being based on random utility theory, from an economics point of view, choice experiments have distinct advantages over the alternatives (Carson 1999), which has made the elicitation method popular in practice. In the context of unfamiliar environment services, choice experiments have a further advantage over CVM because CE is not so constrained. CVM can produce flawed estimates where the resource has never been seen or is difficult to imagine, such that the respondents' preferences in an economic sense for the good cannot be well-defined (Carson et al. 2001).

CE does not require any assumptions to be made about the order or cardinality of measurement (Louviere and Woodworth 1983) and this is one of the major differences compared to CVM. Different sets of alternatives are shown in the questionnaire and respondents are asked to choose their most preferred option (Louviere and Woodworth 1983), offering a flexibility of a choice. The method of CE can also avoid problems such as the un-testable statistical properties of estimated parameters in ranking data and cardinal measurement assumptions in the rating method. It permits the design of choice that imitates real choice environments closely. It is particularly appealing in using the random utility model (RUM) which models the choice of one out of the numerous choices available as a function of the attributes of the good. RUM implies choices that are logical that represent many forms of practical welfare questions on a given choice occasion. The choice set is pre-specified in several levels of attributes which is usually presented to the respondents in a questionnaire format described in an easier form. The alternatives in the set are considered while either holding the attribute levels associated with each alternative constant, or by varying them, within choice sets. The respondent can then select their opinion by making a choice between the different combinations presented. The CE results aims to estimate the relative importance of the individual attributes from the choice set, which can be considered as the trade-offs or marginal rates of substitution that individuals are willing to make between these attributes (Ryan 1996). The total utility that an individual derives from an alternative is determined by the utility to the individual of each of the attributes.

There are other innovative methods of economics such as travel cost method, hedonic pricing, dose-effect method and replacement costs which are usually applied in valuation of coastal resources. The objective of this paper is to reveal problem associated in coastal ecosystem valuation with only CVM and CE using two case studies in Asia and Europe.

Problems encountered in applying CVM and CE methodology and typical data requirement for coastal ecosystem valuation.

The use of two methods in valuation of ecosystem services of coastal areas will be described here using two case studies. One case study was made in developing country setting in Asia using the CVM approach. CVM has proved flexible and is both widely accepted and widely researched (EASAC, 2009). The other case study used the CE approach and the study was made in a developed country setting in Europe.

Case study I[2]:

Stakeholder preference for coastal wetland conservation (preservation) in Muthurajawela Marsh and Negombo Lagoon (MMNL) was revealed in Sri Lanka. The TEV of wetland conservation was estimated using CVM. The field study was used to assess individual's perceptions of conservation on mangroves, clean water and fish stocks, possible uses of the wetlands, respondents' socio-economic background, and to obtain the individual's WTP measure for having a well-conserved wetland. The study focused on the MMNL area, as well as adjacent villages and towns also. These are the areas immediately threatened from development activities and subsequently with the most to gain from conservation (Wattage & Mardle, 2005). Although those who live relatively close to the MMNL would be affected immediately by any developments, the impact of total benefits may be more widespread. However, given time and resource constraints, the study was limited to the MMNL and adjacent areas in which the most significant impact of conservation related cultural and provisioning ecosystem service benefits might be expected.

Two innovative ideas were used in designing the CVM study in MMNL[3]. In this study a relatively new survey-based method known as One and One Half Bound (OOHB) was implemented to ask questions on WTP values. Typically, in dichotomous survey formats of CVM uses single bound or double bound approaches. For example, in using single bound elicitation format a WTP question is asked whether the respondent would like to pay a given amount for a given option, say £5, where the answer would be "yes" or "no". In double bound elicitation format, depending on the response to the first question, a second question will be followed with a different value. A criticism of the double bound approach is that respondents are not told in advance that there will be a second value. As a result, interviews tend to focus on the first price, with the second price coming as something of a surprise when introduced at a later stage. This surprise may cause discrepancy in the responses to the two prices and the OOHB approach[4] is suggested to avoid the problem. Cooper *et al.*, (2002)

[2] This research (Project EMBioC) was funded by the Darwin Initiative of the Department for Environment, Food and Rural Affairs (DEFRA), UK.
[3] The focus of this section is based on the paper by Wattage & Mardle (2008).
[4] Cooper .*et al.* (2002) proposed OOHB survey design, in which the respondent is given two prices in advance and told that while the exact cost of the item is not known for sure, it is known to lie within the range bounded

suggested that eliminating the element of surprise has the potential to remove discrepancies in the responses to the two valuation questions, but that it may prevent being able to ask the second valuation question. That is, the second question will be appropriate half the time, on average. Due to the advantages of this approach, in this analysis the OOHB has been adopted (Wattage & Mardle, 2008). A series of questions were used to verify a hypothetical conservation programme in the MMNL area and the WTP values in the face-to-face survey. The survey was used to uncover peoples' perceptions towards conservation of wetlands in the MMNL area and whether they would be willing to pay the local share of the costs. In brief, the proposed program considers the setting up of an institution to manage and conserve a good fish stock, clean (unpolluted) water and well-grown mangrove (i.e. quality "A" type wetland) in MMNL. A question was also asked about individual's willingness to have a "quality A" type wetland in the area. For the OOHB dichotomous choice format, the value ranges of bids used were *(25,75), (50,100), ((75,125), (100,150)* and *(125,175)*. Starting bid value was selected randomly from the set of prices. Similarly, the first price from the two values in the bracket was also randomly selected.

A total of 358 out of 379 questionnaires were accepted for analysis as such the response rate to the survey was almost 87 percent. In order to analyse the responses to the OOHB surveys, a normal cumulative distribution function (CDF) was applied to the OOHB data. The chi-squared test for significance of regression is 9.66514, which is significant at $\alpha = 0.05$ level of significance. The income variable was found to be not significant due to the wide variation of the income among survey participants. A negative coefficient implies that increases in the parameter have a negative impact on WTP. Data on respondents such as gender, household size and education level were collected and tested as additional parameters. However, these were found to be not significant, indicating that they are not explanatory variables in the calculation of WTP. Following Cooper et al. (2002) a spike model is used to estimate the mean WTP and is calculated by integrating the cumulative density function. The estimated WTP value for the conservation of wetlands in this study amounts to SLRs. 287.02 per month for two years, whereas the estimated median WTP value amounts to SLRs. 264.26 per month for two years.

Estimating non-use value is a controversial issue in valuation studies. The second innovation of this study was the disentanglement of use and non-use value using the method of Analytic Hierarchy Procedure (AHP). The major criticism against the non-use value is that it is motivated by a form of altruism termed "moral satisfaction" or "warm glow" (Kahneman and Knestch 1992), hence, non-use value is not an economic value (Carson et. al 2001). The ability to measuring non-use value is contentious by this argument. However in previous attempts to separate non-use value from the total value, several approaches have been tested (Wattage and Mardle, 2008). In this approach participants were first asked to reveal the total value for wetland conservation and then used a preference disaggregation approach (AHP) to recognise the non-use values. The nature of the question format involved in the non-use value suggests that personal interviews are the best option to elicit preferences.

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by these two prices. One of the two prices is then selected at random, and the respondent is asked whether they would be WTP this amount.

Decomposition of use and non-use values is dependent upon some assumptions. It is assumed that subjects valuing environmental resources have value-motives that are related to use, option, existence and bequest values. These motives are important in a decomposition approach of a total value. It is also important that subjects know the values associated with each of these motives exclusively to separate use and non-use values. It is very difficult to evaluate how subjects might differentiate these estimated values for non-use aspects. Available approaches that are suitable for allocation do not have any solid theoretical foundation (Freeman 1993), as such the decomposition is very tedious. This leads to the conclusion that there is no accepted method to decompose total value into use values and non-use values and to further decompose non-use value into motive-related components (Cummings and Harrison 1995).

AHP could be utilised for this purpose by developing priorities (or weights) for criteria and/or accompanying alternatives. This method was first introduced by Thomas Saaty in the 1970s (Saaty 1977) and has been used considerably in applications since. The AHP is based on a process of paired comparisons across criteria (or attributes) under analysis. The steps of using the AHP process first include the development of a hierarchy of criteria. A survey is developed for pair-wise comparison of criteria to gain the preferences of individuals towards the criteria selected. Finally, the individuals' results are analysed and the aggregate sets of preferences to evaluate the overriding issue are determined. There are several important points that must be ensured during the process, most important is that the hierarchy developed must be representative of the system and not be biased to the modeller's needs and that the objectives listed must be clear and convey the same meaning to all individuals (Wattage and Mardle, 2008). On completion of the survey, the analysis can be made using standard software such as Expert Choice.

AHP has been used in the past to study critical situations scientifically in industry, agriculture and the environment (Mardle *et al.* 2004), however, it has not been used previously to study a situation such as the decomposition of use and non-use values. Total value can be disaggregated to non-use values using the weights allocated to the criteria relating to non-use values. It was assumed that preferences of individuals towards these non-use values indicate the relative importance that they are perceived to have from the resources. The aim of determining 'importance' amongst attributes in the AHP question has clear potential for use as a decomposition method for measuring the impact of the non-use values to the total value. All survey participants who indicated their WTP for wetland conservation were asked to complete the sub-survey of AHP paired comparison to provide preference values for each attribute identified in the analysis (Wattage and Mardle, 2008).

Based on the individual responses, a breakdown of the inconsistency in their responses was attained. Standard AHP practice is to accept responses where inconsistency is less than or equal to 10%. From those who responded in the survey, 101 respondents gave responses to the pair-wise comparison survey with inconsistency less than or equal to 10%, and 99 respondents showed inconsistency between 10% and 20%. Responses with high inconsistency were not included in the analysis as the reliability of their responses could not be ascertained. The aggregated preference towards use value is 0.553 and the non-use value is

0.447 in conservation of wetlands in the MMNL area. The implication of this is that a higher stated use value is associated with lower belief of moral responsibility. The total value wetland conservation of wetlands in the MMNL area as derived through the OOHB method is SLRs. 264.26. So, in this case, TEV can now be split into SLRs. 145.34 for use values and the SLRs. 118.92 for non-use values using the primary results from the AHP (Wattage and Mardle, 2008). The two most important attributes are flood control today (0.254) and future generation use (0.253), where the former is part of the use-value and the latter part of the non-use value. The range of preference is also given for aggregated use and non-use values and shows a particularly insensitive result to changing consistency of responses. The allocation of weights using AHP is a robust method to split total value into use and non-use values. Some researchers consider that the option value should be split between use and non-use values. If that is the case, then the aggregated preference for the use value is 0.453 and the non-use value is 0.547. This implies a stated lower use value that is associated with higher belief of moral responsibility. So, in this case, TEV would be split into SLRs. 119.71 for use values and the SLRs. 144.55 for non-use values.

Case study II[5]:

This section of the paper addresses CE, demonstrating the process of Marine Protected Area (MPA) decision-making and revealing the findings of its application to the determination of MPAs for deep-water Lophelia reefs off the Republic of Ireland. The aim of the approach is to estimate an individual's preferences by establishing the relative importance of the different attributes in valuing aspects of coastal ecosystem services. In terms of MPAs the objective is the determination of the economic benefits of ecosystem protection, which is the difference between the net economic benefits derived from protection and the net economic benefits derived from the resource without protection, with benefits being the net value of costs and including both use and non-use values (Dixon and Sherman 1990, Pendleton 1995).

The survey, conducted as part of PROTECT, was designed to several management scenarios presented in table 1, with its main aim establishing how the Irish public would respond to different attributes of the objectives of managing MPAs. It also incorporated the key features regarded as the most important in the implementation and management of MPAs in Irish deep-sea coral areas. In defining the model structure, care was taken to ensure completeness of the system, such that all major issues related to the deep-sea water corals were incorporated and identifiable in some level. Considerable time was given to clarifying the terms used for the attributes and their underlying implications so that the decision attributes developed were clear and concise. The three main attributes and the associated levels considered in the analysis are shown in table 1. The overriding objective grouping them all was to ensure protection of deep-sea corals while maintaining sustainable fishing practices. While in this case study, only three attribute groups are employed, choice experiment models can generally consider even more attributes and associated levels.

[5] This case study has been produced as an output of the EU 6th Framework funded specific targeted research Project Nu. SSP8-CT-2004-513670 – Marine Protected Areas as a Tool for Ecosystem Conservation and Fisheries Management (PROTECT), www.mpa-eu.net.

In the context for which the levels are developed, they describe distinct cases that could be prescribed by policy on MPAs. For example, the objective of fishing activities allowed in MPAs may be followed and accordingly optimal levels associated with that objective will be maintained. Therefore, the pursuance of this objective will result in a different level of sustainable fishery by controlling fishing activities allowed. In sustainable sense and also achieving the maximum benefits of MPAs, banning destructive fishing gear will make a significant contribution. As these values cannot be measured for the multitude of sub-attributes that exist, the state of the fishery relating to the destructive fishing gear as a management objective is considered. Choice experiment study stated the preference of the individual that is measured towards following this objective. Similarly, preferences were stated for the area related MPA strategy to protect cold water corals and the associated cost that involve in management and monitoring of MPAs.

Table 1: **Attributes and accompanying management objective levels.**

Attributes	*Level I*	*Level II*	*Level III*
1. ACTIVITY – the fishing activity allowed in the MPA	Status quo (allow all fishing)	Ban trawling (but allow other fishing methods)	Ban all fishing
2. AREA – MPA strategy to protect cold water corals	Status quo (currently identified coral reefs)	All known coral reefs	All coral areas (where coral reefs are thought to exists)
3. COST– management & monitoring cost	€ 0 (No additional tax)	€ 1 (Additional yearly tax)	€ 10 (Additional yearly tax)

Source: Final Report, PRPTECT Project, CEMARE, University of Portsmouth.

The three attributes and three levels (3^3) in table 1 produce a total of 27 different combinations using a main effects design. With the ADX Interface for design of Experiments (SAS 9.1), an orthogonal main effects design (where all interactions are assumed to be insignificant), this was subsequently reduced to nine profiles for use in the study.[6] These nine profiles with their component attributes and levels were then incorporated into a postal questionnaire format, using the most popular presentation approach - profile picture cards with a verbal description of the attributes and associated levels. The description of attributes is crucial to ensure that each respondent understands the meaning of each attribute. The questionnaire was designed to include all the 9 profiles/choices on one card and respondents were asked to select their most preferred option out of the 9 presented to them.

[6] The nine profiles given using an orthogonal main effects plan were arrived at by identifying a subset of the full set where each linear combination of attributes of the full set can be achieved. That is, the subset still enables the analysis of all alternatives to be made.

The design strategy of presenting all 9 choices in the one card was found during piloting to be acceptable without invoking an information overload. It is also easier for respondents to compare the options when they see all the available options on one card rather than singularly. The data representation for such single choice selections consists of one observed choice and eight unobserved subsequent choices. In addition to the choice behaviour questions, a number of socio-economic questions important for the analysis were incorporated in the questionnaire. These were useful in interpretation and validation of the results and were distributed during the latter part of the summer of 2007. A randomly selected sample of 5000 residents of the Republic of Ireland was selected, ultimately achieving a response rate of just over 500 (1:10), which with the questionnaire format generating 9 choice responses for each respondent created a robust data set. It is worth noting that unlike many choice experiment analysis studies, which analyse the responses of a homogeneous survey set, this survey in targeting the residents of the Republic of Ireland has dealt with a particularly heterogeneous population.

For the analysis of the model SAS/STAT has been used. The SAS/STAT software does not have a procedure that is specially designed to fit the conditional logit models (CLM). However, with some modification to the data entry procedure, the PHREG procedure can be used to fit these models. First, the importance of each attribute model was estimated using the PHREG[7] procedure in SAS (SAS Institute Inc., 1999). PHREG was designed to do Cox regression analysis of continuous-time survival data, using the method of partial likelihood to estimate a proportional hazards model. Further, PHREG has the unique option for handling tied data, as such the range of CLMs estimated are much broader than most Cox regression programmes or even programmes specifically designed to estimate discrete choices. The result proves that PHREG is one of the best procedures available in statistical tests for handling discrete choice problems.

Table 2: Model test statistics (global H_0: $\beta=0$).

Test	χ^2	*DF*	*Pr* > χ^2
Likelihood Ratio	228.4524	6	<0.0001
Score	254.2180	6	<0.0001
Wald	214.6333	6	<0.0001

Source: Final Report, PRPTECT Project, CEMARE, University of Portsmouth.

Several chi-squared likelihood ratio tests were carried out to find out the significance of the model used in the analysis. The first one is the *likelihood ratio chi-square* obtained by comparing the log-likelihood for the fitted model with the log-likelihood for a model with no explanatory variables. The ratio was calculated by taking twice the positive difference in the two log-likelihoods. The *score* is the second test used in the model and this statistic is a

[7] This procedure fits the Cox proportional hazards model to survival data. The partial likelihood of Breslow has the same form as the likelihood in a conditional logit model.

function of the first and second derivatives of the log-likelihood function under the null hypothesis. *Wald* chi-squares are the third test in this category reported by the model, which are calculated by dividing each coefficient of the maximum likelihood estimates by its standard errors and squaring the results. The estimated chi-squared values for likelihood ratio, Score and Wald statistics indicate that the model is very highly significant (table 2). At a significance level of α = 0.01, reject the null hypothesis of no relationship between choice and the attributes. In fact all three model tests indicate a high level of significance with probability <0.0001, indicating that there is a strong relationship between choice and the attributes.

Estimated parameters values of the model and their related statistics are presented in table 3. As shown in the table, some of the parameter values are not significant to at least the $\alpha=0.10$ level. Model descriptive labels for all variables are presented along with the zero coefficients for the reference levels (i.e. status quo of area and activity and the zero cost). Coefficients for the other estimated of the model have values relative to the reference level. Under the attribute of AREA, the part-worth utility (i.e. the estimated coefficient) for the variable status quo (currently identified coral reefs) is a structural zero, while the part-worth utility for "all known corals" is + 0.47889 and "all coral areas" (where coral reefs are thought to exist) is + 1.16258. Hence, the protection of all known corals is preferred over the status quo and the protection of all corals is preferred over both the status quo and the protection of known corals. The magnitude of the estimated coefficient indicates which objective is more preferred by the sample respondents. The success of the MPA is dependent upon the control of the fishing area and the survey reveals that the Irish public prefers the control of "all coral areas". Both parameters tested under this first attribute proved very highly significant as indicated by the *Pr > chi-squared* values. Both values proved significant even at α = 0.01 levels.

The second management attribute tested in the model was the "ACTIVITY", the fishing activity allowed in the MPA. These activities are important in regulating ecosystem services because these human induce activities alter the natural regulating process. When compared to the status quo (allow all fishing), the trawling ban (with other fishing methods allowed, i.e., netting, lining and potting) and a ban on all fishing were preferred, with the magnitude of the estimated parameter indicating that the trawling ban (+1.27199) was preferred over a ban on all fishing (+0.20468). However, only the trawling ban variable in this attribute proved significant at $\alpha=0.01$ level, with the part-worth utility for the status quo in MPA management a structural zero. A ban on all fishing was shown to be preferred over the reference objective, allow all fishing (status quo), however, the parameter proved not to be significant, even at $\alpha=0.10$ level. While the trawling ban (+1.27199) appears to be the preferred managementoption, maintaining successful MPAs has been shown to be a general preference of the Irish public. The general consensus of Irish general public is to ban destructive trawl fishing in MPA associated fishing grounds. The third management attribute tested in the model was "COST" (e.g. management and monitoring cost). This willingness to pay (WTP) value was designed as a payment of an additional yearly tax contribution per person towards the maintenance of MPAs.

Table 3: Analysis of maximum likelihood estimates for all respondents

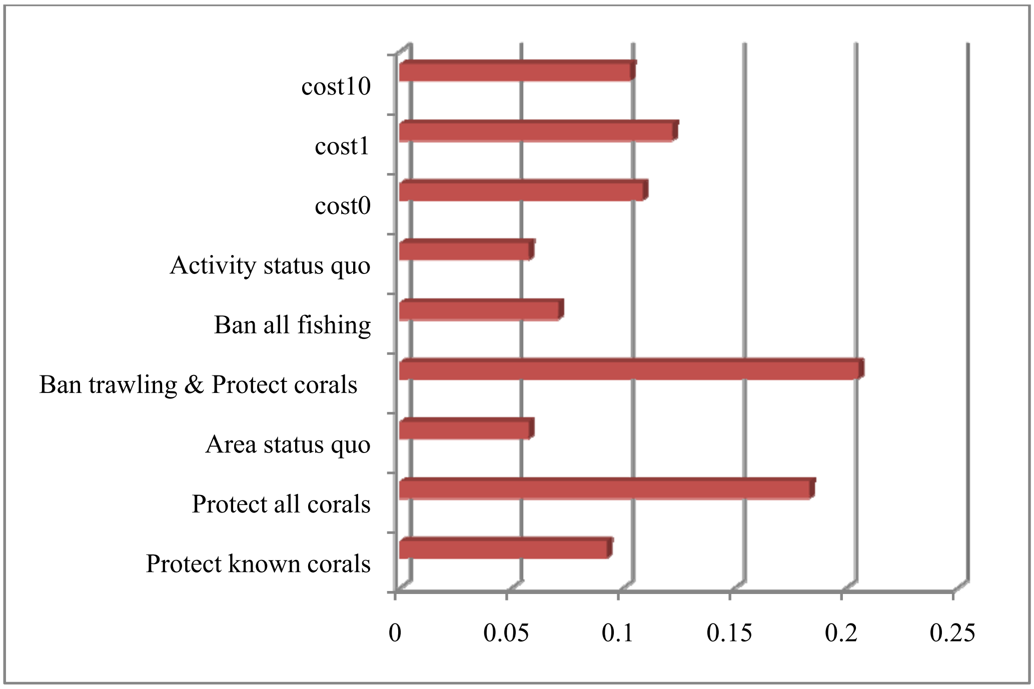
Parameter Variable	*Estimate*	*S.E.*	χ^2	*Pr* > χ^2
AREA				
Known corals	0.47889	0.16127	8.8214	0.0030
All corals	1.16258	0.14568	63.6878	0.0001
Status quo	0	.	.	.
ACTIVITY				
Ban trawling	1.27199	0.14032	82.1759	0.0001
Ban all fishing	0.20468	0.16372	1.5628	0.2113
Status quo	0	.	.	.
COST				
One Euros	0.11777	0.13737	0.7350	0.3913
Ten Euros	-0.05132	0.13727	0.1398	0.7085
Zero Euros	0	.	.	.

Source: Final Report, PRPTECT Project, CEMARE, University of Portsmouth.

The status quo was set as €0 (no additional cost) and compared to a €1 additional yearly tax and a €10 additional yearly tax. The results reveal that €1 was favoured over the status quo with a €10 tax less favourable than both the status quo and a €1 tax. All parameters proved insignificant even at the $\alpha=0.10$ level indicating that the attribute of COST was not a significant determinant of preference on this issue.

The parameter estimates in table 3 were used to estimate the probability of each of the 9 presented being chosen. Looking to the consensus of opinion, using the choice probabilities, it is possible to get a crude indication of the importance/preference attached to each of the individual objectives arising out of consensus. One way of doing this is to take a simple average of probabilities for each attribute, the results of which are shown in figure 2. As shown in the figure 2, the ranking of attributes and levels suggests that the top 2 preferences for MPA management are to ban trawling and to protect all coral areas. Payment of €1, €0 and €10 comes as the next preferred options which can be expressed as the WTP values for the agreed activities. These results are largely as expected, given the results of the table 3 and confirm the level of importance attached by the Irish public to MPAs in the Irish deep-sea coral areas and the banning of destructive fishing methods such as trawl fishing for the protection of those reefs.

Figure 2: Rough estimation of the degree of importance attached to each attribute (derived from the full set of 27 alternatives)



Source: Final report, PRPTECT Project, CEMARE, University of Portsmouth.

Problems encountered in this approach in valuation of regulating ecosystem services

As shown in the two case studies above, non-use (passive use) values can be derived using appropriate estimation methods. The examples show the values for cultural services which people place on the existence of mangroves and water (case study I) and the deep-sea corals of a MPA (case study II). As shown in case study I, the separation of use values and non-use values and to further sub-components of non-use (i.e., option, existence and bequest described in figure 1) are also possible using appropriate methods. The provisioning ecosystem service relates to products such as food, materials for construction and energy that can be directly obtained from biodiversity which is controlled by the price system. Any misuse or over-use of these products is naturally controlled by the price mechanism. The cultural services relate to those non-material benefits which people obtain from ecosystem through recreation and aesthetic experiences that can be estimated through revealed preference techniques such as travel cost and hedonic pricing methods. Biodiversity related regulating service is a complex concept and attempts to assess the value have proved to be challenging compared to other aspects of values. Price based approaches are mostly accurate to value provisioning services and this can also be used to assess the costs of environmental degradation of an important habitat by assessing the cost involved in artificially replacing the lost regulating services. A simple example of replacement cost involves estimating the cost of replacing the water filtrations services provided by undeveloped watershed with a water filtration plant. Human built systems could be effective, however, no human built system can provide all of the ecosystem services of a natural system and as such the replacement cost is only an approximate value. Supporting ecosystem services relating to those factors can enable all of the three categories to take effect. They are different to provisioning, regulating and cultural services; however without the help of supporting services biodiversity will have a substantial detrimental effect on the condition of all of these ecosystem categories and thus on human welfare and livelihood.

One way to protect the regulation of services of the ecosystem processes is to introduce MPAs. This approach cordons off certain areas and restrains the use of available services. One big argument against the MPAs is that they are too small and isolated to sustain the full range of regulating ecosystem services. However, conservation of ecosystems in general is the only solution remaining in order to protect the ecosystems. As noted, the initial approach was a regulatory one, which includes the protected areas and rules that prohibit farming on land slopes and use of pesticides in riparian areas. The use of market instruments to promote conservation has also been introduced more recently (Landell-Mills & Porras, 2002). The success of MPA or conservation approach is dependent upon the cost and benefits. The cost of conservation includes both the direct cost of implementing conservation measures and the opportunity costs of foregone uses. The benefits of conservation include preserving the services that ecosystem provides and the only way to quantify such benefits is asking the people who use the service as discussed in case study II. However, the major problem encountered in this approach in valuation of regulating ecosystem services is allocating total benefits among cultural and regulating services.

Policy options and recommendations

The concept of coastal ecosystem services is still ambiguous and valuing ecosystem services is more complex, especially for regulating services. As described above, different methods of economic valuation are applicable to different ecosystem services. With greater difficulty replacement cost can be used to value some aspects of regulating services, however, it does not encapsulate all of the values consistently provided by an ecosystem. In coastal ecosystems this value can be approximated by applying the avoided cost or replacement cost methods. The avoided cost method calculates the economic value of benefits that are provided by an ecosystem, which may not be robust if the character of the ecosystem was fundamentally different. As such, avoided cost can be calculated by estimating the cost of replacing the existing ecosystem with a restored system (built substitute). Two case studies presented in this paper demonstrated the use of CVM and CE for valuing aspects of non-use values, i.e., bequest and existence values. Cultural service values are typically non-use values and they can be easily estimated using stated preference methods. Provisioning services are the easiest service to value among the ecosystem services mainly because of the established market place, hence prices. Consumer surplus is the widely known approach and the easiest approach to find out the real value. In the absence of market place and prices non-use values are not straightforward to estimate, however with the available modelling approaches and advances in computer programming over the last few decades, the technology is growing rapidly. By identifying which particular valuation methods would be more appropriate for valuing particular types of services, it might be possible to determine which ecosystem services might be valued relatively rapidly and cheaply. It is the task of the manager to decide what methods are more robust compared to others. It is very important to keep in mind that ease of valuation does not correspond with the importance of a given service. There is an urgent need for research to determine the status of regulating services and how the value can actually be captured and incorporated in decision making processes in ecosystem management.

As pointed out in the Millennium Ecosystem Assessment all ecosystems provide multiple services although the relative importance will vary from system to system. The interaction between different services is complex, a pertinent example is the complementary relationship between some services, such as nutrient cycling (regulating) and primary production (provisioning) ; enhancing one will enhance the other. Hence, management of an ecosystem for provisioning services, in particular, tends to reduce their ability to provide regulating and cultural services. Unless there is advanced research on biological functions and interactions the valuation of these services may not be proven successful.

Intensive agricultural development and urban landscape modifications globally have profoundly affected the integrity of ecosystems. The focus of intensive agricultural development is exclusively on the production of food to meet the growing demand for food from an escalating world population. This is at a huge cost, such as carbon storage for climate regulation through diminishing water quality to cultural services, coined as "externality". The goods produced in provisioning services can easily be valued using market mechanism; hence the focus of the world towards such goods as the externality was not entered in to the equation. Moreover, other services such as regulating lack markets, therefore little or no attempt to incorporate these methods into economic planning process. Future actions need to consider this discrepancy and should initiate more policy research on the subject and provide direct support to the maintenance of healthy ecosystem.

Conservation decisions should not only be based on economic criterion. Other criteria such as ethical, cultural and historical factors also play a pivotal role in this connection. Valuation can only provide relevant information highlighting the economic consequences of alternative courses of action. As such economic valuation of ecosystem services will lead to more informed choices if used correctly in decision making processes. However, existing economic valuation techniques can provide reliable answers to questions involving relatively small scale changes in resource use and only become less robust as the scale of the analysis and the magnitude of environmental change increases. Furthermore, economic valuation tends to deal poorly with large scale ecosystems and long time horizons. Cost-benefit analysis in decision making becomes more difficult when there is an uncertainty about future benefit flows of ecosystems and the role of discounting become increasingly detrimental.

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