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Guidelines on Environmental Valuation

PMO note: This document was submitted to the Second Meeting of the Regional Working Group for the Investment Component (14-17 November 2005 in Jeju, Korea). The Meeting agreed on the basic outline of the guideline and decided to finalise the theory section by the end of December 2005. The Meeting also agreed to focus on tourism and mariculture as the initial targets. The Valuation studies for these two targets will be conducted from January 2006 through August 2006. The other targets including commercial fisheries will be identified and addressed, if necessary, at a later stage.

Economic analyses of marine ecosystems: A guideline for valuing environmental services in the Yellow Sea

Yellow Sea Large Marine Ecosystem (YSLME) Project
Project Management Office

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1. Introduction

People benefit from numerous gifts from the sea. We eat sea food, enjoy beaches, and trade goods by ship. We also depend upon the sea to provide essential services for life, such as nutrient cycling, primary production, and climate regulation: Without these services, no life could exist. However, anthropogenic activities cause troubles to this Mother Nature. Due to a massive expansion of population as well as economic activities, the marine and coastal ecosystems, especially in Asia, suffer from a number of environmental problems. For example, in the Yellow Sea ecosystems, the main focus of this guideline, overfishing, water pollution, and species and habitat losses have become problematic. To address these problems, the policy-makers and researchers in the region have continued extensive discussions and research activities since the late 1990s with the cooperation of the United Nations Development Programme and the Global Environment Facility. As part of such global efforts, this paper—a guideline for valuing environmental services in the Yellow Sea—provides an approach to address the issues in the Yellow Sea from socioeconomic perspectives. The overview of this guideline is the following.

Aim of the guideline

Focusing on the Yellow Sea, the guideline aims to present a framework as well as a methodology to assess the economics (benefits[1] and costs) of the goods and services that marine and coastal ecosystems provide. Using this guideline, the conservation practitioners could properly conduct economic analyses so as to obtain insights into the socioeconomic aspects of both the concerned ecosystems and the efforts to protect them.

Target audience

The guideline mainly targets economic researchers to assist them to analyse the benefits and costs of marine and coastal environment. However, a wide range of audiences, including policy-makers, development planners, and scientists in different fields would benefit from this paper through an understanding of the prospects and procedures of the expected economic analyses. In addition, while the focus of this guideline is on the Yellow Sea ecosystems, those who are interested in conserving marine and coastal ecosystems in different regions might find the information of the guideline useful to implement similar economic analyses for their concerned environments.

Rational for the guideline

This guideline may considerably contribute to the existing relevant literature. A number of studies have revealed the values of various aquatic environments. Even guidelines are available for specific biomes such as wetlands, coasts, or protected areas (Barbier et al., 1996; Penning-Rowsell et al., 1992; Task Force on Economic Benefits of Protected Areas [TFEBPA], 1998). However, few literature address the environmental problems of marine and coastal ecosystems on a scale similar to this guideline. The scope of this guideline is broader, covering not only wetlands and

[1] Ecologists and economists may think differently the benefits of the goods and services that ecosystems provide. The former might argue the intrinsic worth of ecosystems as their benefits, while the latter think about the benefits in terms of money or commodities.

coasts but also open ocean. The guideline also describes the foundation of benefit-cost analyses and the effective presentation of their results, which, despite their importance, are largely missing from most of the existing literature.

Structure of the guideline

The guideline consists mainly of two parts: conceptual framework and practical methodology. The following Chapter 2 constructs a framework for the analyses. Presenting the problems of the Yellow Sea ecosystems as well as the economics of ecosystems, this chapter discusses possible techniques and processes to assess the net benefits of ecosystem goods and services. Chapter 3 then provides methodologies to evaluate specific goods and services that the Ecosystems offer. Based on the framework discussed in the previous chapter, this chapter reviews the relevant existing studies, identifies the applicable valuation methods, and suggests both the detailed procedures for collecting and analysing data and the formats for presenting the findings.

2. Conceptual framework

2.1 Problems of the Yellow Sea Ecosystems

Marine and coastal ecosystems suffer from serious environmental degradation which is attributable to various anthropogenic causes, though these ecosystems provide people with a number of useful goods and services. For example, the Yellow Sea ecosystems, a semi-enclosed water area adjacent to mainland China and the Korean Peninsula, has experienced for a long time a range of problems such as the degradation of water quality, the decline of fish stock, and the loss of biodiversity. Defining both the marine and coastal ecosystems and the services that they provide, this section discusses the Yellow Sea ecosystems and their environmental problems.

Definition of marine and coastal ecosystems

A marine ecosystem is an ocean with a water depth of more than 50 meters, while a coastal ecosystem is an interacting boundary between ocean and land with a range of 50 meters below and above the sea level. An ecosystem is “a dynamic complex of plant, animal and micro-organism communities and their nonliving environment interacting as a functional unit” (United Nations, 1992 cited in Millennium Ecosystem Assessment [MA], 2003, p. 51). With this notion of ecosystem in mind, MA (2003) defines a marine ecosystem as an “ocean, with fishing typically a major driver of change” and a coastal ecosystem as an “interface between ocean and land, extending seawards to about the middle of the continental shelf and inland to include all areas strongly influenced by the proximity to the ocean” (p. 54). Under this characterisation, the boundary of the former ecosystem is defined as the area which is more than 50 meters below the surface of the sea, whereas the boundary of the latter ecosystem is defined as the area between up to 50 meters below and above the surface of the sea. Following the MA’s definition, and considering the special characteristics of the Yellow Sea, hereinafter, this guideline refers to the marine ecosystem as the term which means both the marine and coastal ecosystems, unless otherwise stated.

Ecosystem services

The marine ecosystem provides a diverse range of services. “Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions” (Costanza et al., 1997, p. 253). For convenience, hereinafter, the term "ecosystem services" includes both "goods" and "services" in this guideline. Based on their functions, MA (2003) classifies ecosystem services into four groups: provisioning, regulating, cultural, and supporting services. Table 1 summarizes these groups with examples of specific services.

Table 1. Ecosystem services

Provisioning services Products obtained from ecosystems	Regulating services Benefits obtained from regulation of ecosystem processes	Cultural services Nonmaterial benefits obtained from ecosystems
• Food • Fresh water • Fuel wood • Fibre • Biochemicals • Genetic resources	• Climate regulation • Disease regulation • Water regulation • Water purification • Pollination	• Spiritual and religious • Recreation and ecotourism • Aesthetic • Inspirational • Educational • Sense of place • Cultural heritage
Supporting services Services necessary for the production of all other ecosystem services		
• Soil formation	• Nutrient cycling	• Primary production

Source: MA, 2003, p. 57

Provisioning services mean the products of ecosystems (e.g., food, fuel wood). Regulating services are the benefits of regulating ecosystem processes (e.g., water purification, climate regulation). Cultural services are the nonmaterial benefits that people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences (e.g., cultural heritage, tourism). Supporting services are those that are necessary for the production of all other ecosystem services (e.g., nutrient cycling, primary production). According to Pagiola et al. (2004), the marine ecosystem provides most of the above services.

Yellow Sea Ecosystems

Bordering three countries—Democratic People's Republic of Korea (DPRK), People's Republic of China (China), and Republic of Korea (ROK)—the Yellow Sea ecosystems are the semi-enclosed body of water with the area of about 400,000 square kilometres. The floor of the Yellow Sea, submerged post-glacially, is geologically unique. The seafloor has an average depth of 44 meters with the maximum depth of about 100 meters. The slope of the seafloor is gentle near the Chinese continent while the slope is steep toward the Korean Peninsula. The Yellow Sea is connected to the East China Sea in the south, forming a linked circulation system. With their high primary productivity, the Yellow Sea ecosystems support substantial populations of fish, invertebrates, marine mammals, and seabirds. In addition, people in the adjacent countries have benefited for hundreds of years from these abundant gifts from the Sea (Yellow Sea Large Marine Ecosystem [YSLME] Project, 2000).

Serious ecological destruction becomes obvious in the resource-rich Yellow Sea ecosystems as the population grows and the economic activities accelerate in neighbouring nations. The YSLME Project (2000) reports various problems, including the following: (i) the decline of commercial fish, (ii) the loss of biodiversity, (iii) the degradation of water quality, (iv) the adverse impacts on human health, and (v) the outbreak of Harmful Algal Blooms. Both the loss of opportunities for recreation and tourism and the damage to coastal infrastructure are also major concerns (YSLME Project, 2005a; 2005b; 2005c; 2005d). Anthropogenic activities such as fishing, mariculture, and tourism might cause these problems (YSLME Project, 2005e).

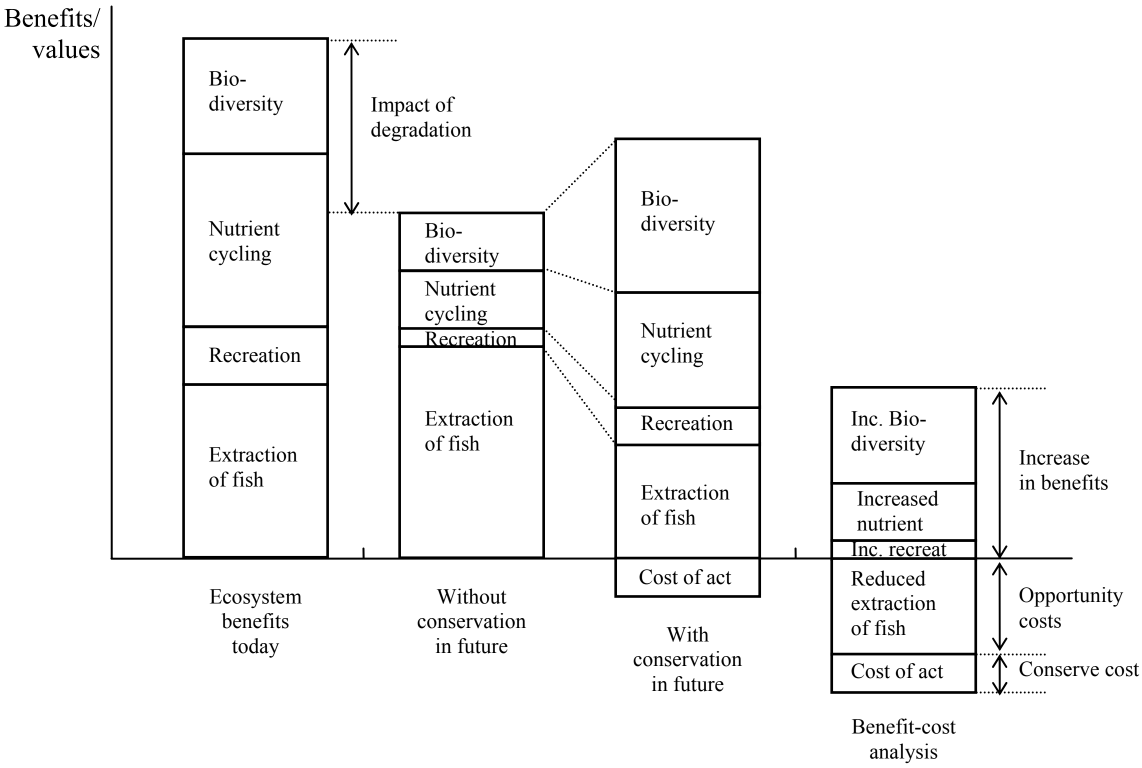
2.2 Economics of ecosystems

Economic aspects could contribute significantly to the successful conservation of ecosystems. Analyzing economic benefits and costs of the concerned environment would provide decision-makers with an idea of how much conservation effort they should make. The economic analysis would also help conservation practitioners recognise the efficiency of their programmes or projects. Other stakeholders including the general public could realize the importance of conserving ecosystems from the perspective of economy in addition to that of ecology. This section, based on the theory of environmental economics, discusses the foundation of benefit-cost analyses, followed by the concept and types of economic values. The approaches to value ecosystem services are also examined.

Benefit-cost analyses for decision-making

Economics provides simple yet effective criteria for decision-making: Comparing the gains (benefits) with the losses (costs) of an action, if the former exceeds the latter, support the action; otherwise, oppose it (Tietenberg, 2003). These normative criteria, a foundation of benefit-cost analyses, help decision-makers answer difficult questions such as: Should we preserve wetland or convert it to agricultural land? Should we regulate fishing effort to preserve fish stock? Should we control emissions from industries to prevent water pollution? By assessing the net benefits (the difference between benefits and costs) with or without each action (i.e., preserving wetland, regulating fishing efforts, controlling emissions), decision-makers can determine whether they should take the action. If the net benefits are positive, the decision-makers would proceed with the action. These criteria are preferable for the society as a whole because employing them prevents resources from being wasted by not taking actions that have fewer net benefits.

The benefits of ecosystems, as described further in detail subsequently, can be derived in the form of total willingness to pay from the demand for the services that the ecosystems provide. Note that the term "benefits" and "(economic) values" are used interchangeably in economics and that this guideline follows this custom. The costs of ecosystems are measured as opportunity costs—the forgone net benefits—which otherwise would be realized in other beneficial uses (Tietenberg, 2003). If additional costs, other than opportunity costs, accrue to generate ecosystem services (e.g., the management cost of mangrove forests to produce timbers), these extra costs should also be included in the calculation of the total costs. Properly measured, the benefits of ecosystem services today might be illustrated as the first column of Figure 1.



Source: Adapted from Pagiola et al., 2004, pp. 19-20

Figure 1. Benefit-cost analyses of conserving ecosystems

Suppose that these benefits will decrease at some future time because of environmental degradation; then, the benefits would look as the second column. (This situation is a "baseline", which is defined as the "reality in the absence of the regulation" (U. S. Environmental Protection Agency [U.S. EPA], 2000, p. 21).). The difference in the number of benefits between today and sometime in the future is the impact of degradation. However, with conservation efforts implemented, this impact might be less (the third column). Comparing the results of the above two scenarios, with or without the conservation efforts, would reveal the net increase in ecosystem benefits. Moreover, the information of these two kinds of ecosystem benefits contribute to the subsequent benefit-cost analysis. In the benefit-cost analysis, the increased benefits as a result of implementing conservation activities are compared with the sum of the opportunity costs of forgone benefits and the costs of the activities, if any. As mentioned early in this section, if the benefits exceed the costs, it is reasonable to support the conservation activities. It is important to note that this analysis should compare the benefits and costs *with or without* the activities, rather than *before and after* implementing them (i.e., the ecosystem benefits today and those in the future with conservation efforts), as many other factors may have changed in the period of intervention (Pagiola et al., 2004).

If the benefits and costs accrue over time in various timings, the analyses must consider it. To incorporate this time factor, the analyses assess the net present value (NPV) of a stream of net benefits {B_0, B_n} that arise over time, which is computed as

$$NPV[B_n] = \sum_{i=0}^{n} \frac{B_i}{(1+r)^i}$$

where *r* is the appropriate interest rate and B_i is the net benefits accruing in various timings. The idea of this calculation is to discount future net benefits by the interest rate so that they represent today's values; therefore, this interest rate is also called a discount rate. After discounting, the same normative criteria can be applied: If the NPV of a stream of net benefits is positive, support the action; otherwise, oppose it (Tietenberg, 2003).

Setting the discount rates is not an easy task. There is neither a single rate to apply nor a consensus on how to set the rates. However, for practical purposes, U.S. EPA (2000, pp. 48 and 52) suggests the following as a guide to specify the discount rates.

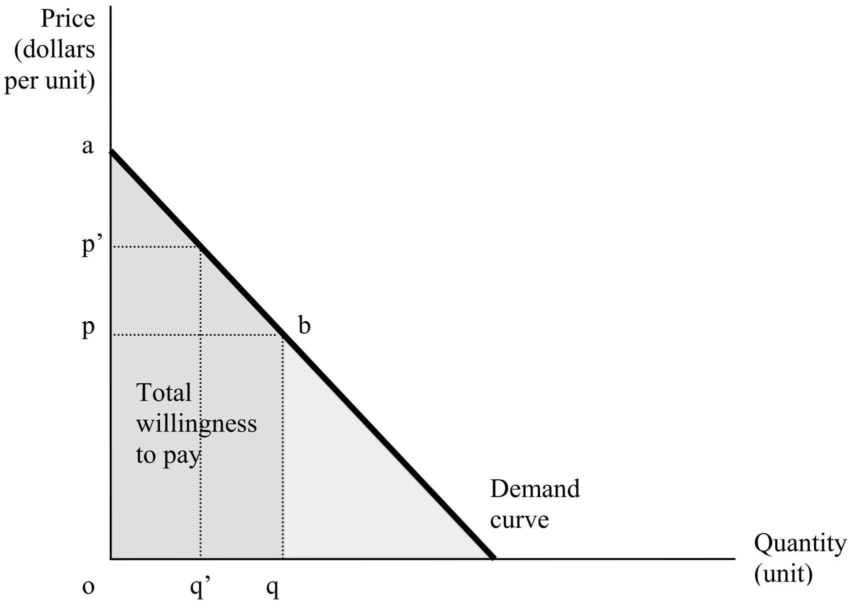
- First, for the intra-generational discounting (a relatively short term, e.g., several decades), use the historical rates of return on relatively risk-free investments such as government bonds, which are adjusted for taxes and inflation (i.e., two to three percent in the U.S. case).
- Second, consider also applying an estimate of the average real pre-tax rate of return which is generated by private sector investments (i.e., seven percent [U. S. Office of Management and Budget, 1992]).
- Third, conduct sensitivity analyses at different discount rates ranging from the rates of return of the relatively risk-free investments to those of the private sector investments (e.g., four to six percent).
- Fourth, present the undiscounted streams—in addition to the discounted summation (i.e., NPV)—of the benefits and costs.
- Fifth, for the inter-generational discounting (a long term, e.g., more than decades), use a rate of zero percent. Sixth, consider that sensitivity analyses may be as helpful for the inter-generational issues as for the intra-generational ones.

Economic value

Recognising what "value" means may vary from person to person; King and Mazzotta provide a useful summary of the theoretical aspects of economic value.[2] Economic value (or benefits) of a good or a service—for convenience, a service—is measured by the maximum amount of other services that a person is willing to give up in order to have that service. Since it represents how much of all other services that he/she is willing to give up to obtain the service, the monetary value that the person is willing to pay for that service is commonly used to measure the economic value of the service. In other words, the economic value of the service is measured by the willingness to pay for it.

The willingness to pay for the service (often referred as WTP) can be derived from its demand. Assuming that the price of other services and the income of the person remain constant, the demand for the service increases as its price decreases. Figure 2 shows this inverse relationship between the price of and the demand for the service. The graphical representation of the relationship is called a demand curve.

[2] Freeman (1993) and Tietenberg (2003) also present useful insights on the concept of economic value and on its valuation; see pp. 6-8 and pp. 20-22, respectively.



Source: Tietenberg, 2003, p. 22

Figure 2. Relationship of demand to economic value

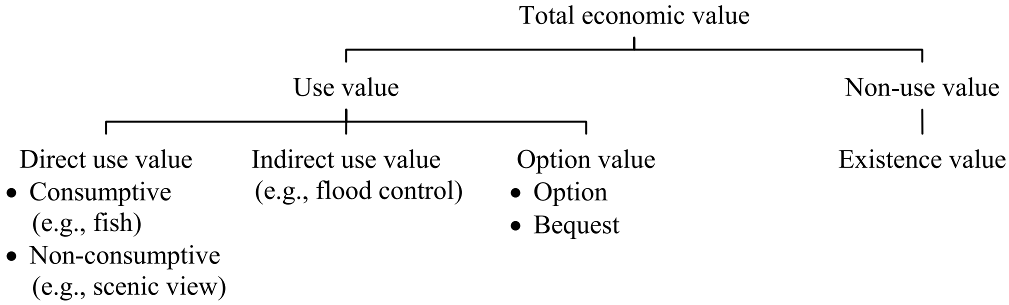
The demand curve tells how much services the person (or consumers as a whole, if aggregated) is willing to buy at various prices. Two points are noteworthy: First, the demand curve depicts the locus of his/her maximum willingness to pay for the service. Second, his/her total willingness to pay can be measured by calculating the area under the curve to the allocation of interest. Suppose a service is provided at the price of *p* and with the quantity of *q*; then, the area *abqo* represents the total willingness to pay for—i.e., the economic value or the benefits of—the service. If the demand curve is individual, the aggregated economic value for the society as a whole can be estimated by taking the individual total willingness to pay multiplied by the total number of people who are relevant to the ecosystem service (U.S. EPA, 2000).

It is incorrect to assume that the price of the service (whether it is a market price or an implicit one) represents its maximum willingness to pay. The price tells only the minimum willingness to pay of the person; in other words, the willingness to pay for the service is always equal to or greater than its price. For example, in Figure 2, the willingness to pay for the *q*'th service is *p*', while the price of that service is *p*: Note that the willingness to pay is greater than the price (*p*' > *p*).[3] Due to limitations in available data or resources, however, the existing prices of concerned ecosystem services as well as the estimated costs relevant to them (e.g., the costs to restore or replace the services) may be used as the proxy for the maximum willingness to pay for the services (Asian Development Bank [ADB], 1996).

[3] Suppose that you bought a car which cost 10,000 U.S. dollars (USD) and that you might have been willing to pay more for that car, for example, up to 12,000 USD, considering the utility of having that quality car. Then, the market price (10,000 USD) is the *minimum* economic value of this car for you, while the *maximum* willingness to pay or the *maximum* economic value of the car is 12,000 USD.

Types of economic values

There is a broad consensus on the typology of economic values, as various literature point out (Pagiola et al., 2004; Tietenberg, 2003; U.S. EPA, 2000). Total economic value mainly consists of the following two components: use value and non-use value. The use value is further divided into three groups: direct use, indirect use, and option value (Figure 3).



Source: Pagiola et al., 2004, p. 9

Figure 3. Typology of economic values

The direct use value reflects the benefits from using the provisioning services and cultural services of ecosystems. These services include the fish harvested from the sea and the scenic beauty of a natural vista. Note that, as these examples indicate, the direct use value includes not only consumptive services (fish) but also non-consumptive ones (scenic views), and that the services may or may not be traded in the market. The indirect use value reflects the benefits from using the regulation services or supporting services of ecosystems. These services include the storm protection function of mangrove forests and the nutrient cycling function of the sea. It is notable that the services tend to be public in nature; in other words, they are neither excludable nor rival in consumption. The option value reflects the benefits that people receive from holding a future ability to use the ecosystem services. People preserve the services either for themselves (option value) or for others/heirs (bequest value). The non-use value, also known as existence value, reflects people's willingness to pay for improving or preserving ecosystems that they will never use. For example, people may be willing to pay for preserving the Grand Canyon, though they never visit this unique resource.

Approaches to value ecosystems

Broadly speaking, there are two approaches to measure the total economic value: "effect-by-effect" or "comprehensive" approach (U.S. EPA, 2000, p. 62). The former is to evaluate ecosystem services (e.g., biodiversity, nutrient cycling, recreation, or fish extraction) separately and then to sum these individual measures to comprehend total benefits. On the contrary, the latter is to assess the whole benefits collectively by using, for example, the contingent valuation method or the benefit transfer method. These methods, discussed in detail in the following section, are also used for estimating the values with the effect-by-effect approach.

The effect-by-effect approach is more widely exercised than the comprehensive one because of, for instance, the technical and budget constraints. In addition, the effect-by-effect approach may be preferred since it is difficult to assess through the comprehensive approach the change of benefits which is attributable to conservation efforts. (Nevertheless, the comprehensive approach is still useful in not only reducing the need to value each service discretely, but also identifying the upper bound of the total value which is estimated with the effect-by-effect approach.) It is also noteworthy that, as literature implies, valuation exercises should focus on the individual ecosystem services which are most likely to affect the result of benefit-cost analyses because the resources for the exercises are finite. In other words, ignoring the services that would not affect the result is legitimate (ADB, 1996, p. 13; TFEBPA, 1998, p. 17; U.S. EPA, 2000, p. 22).

2.3 Methods for measuring the benefits/value

Various methods are available to measure economic values. According to ADB (1996), there are two main types of methods: primary and secondary methods. The former requires collecting and analysing field data (i.e., primary information source), while the latter uses the findings of the studies that employed primary methods (i.e., secondary information source). Discussing the primary methods followed by the secondary ones, this section overviews the major techniques to value the benefits of ecosystem services. At the end of this section, the application of the methods which are commonly used for measuring specific economic values is also described.

Primary valuation methods

The primary methods can be classified further into the following four categories: direct observation, direct hypothetical, indirect observable, and indirect hypothetical (Table 2). Tietenberg (2003, pp. 38-42) and U.S. EPA (2000, pp. 71-87) mainly provide a useful summary for this section.

Table 2. Primary valuation methods

Methods	Observed behaviour	Hypothetical
Direct	Market price Simulated markets	Contingent valuation
Indirect	Travel cost Hedonic property values Hedonic wage values Avoidance expenditures Cost-of-illness Cost-of-restoration/replacement	Contingent ranking

Source: Adapted from ADB, 1996, p. 32; Tietenberg, 2003, p. 39; and U.S. EPA, 2000, pp. 81-83

First, the direct observation methods derive the benefits of ecosystem services, if their market exists, using the data on actual transactions. For example, using the observable market prices of fish could help in assessing the value of commercial fish and its losses due to water pollution. With its demand and trade volume estimated, it would be possible to calculate the value of (i.e., the total willingness to pay for) fish. Since the markets for most of ecosystem services do not exist, however, the use of the direct observation methods might be limited; then, alternative methodologies which are discussed as follows would become necessary.

Second, the direct hypothetical method, known as contingent valuation, estimates the benefits of ecosystem services from the survey results on individuals' willingness to pay for the services. Providing plausible hypothetical scenarios (i.e., carefully describing the current and future status of concerned ecosystems with or without conservation efforts), this method asks respondents either how much they would pay or whether they would pay a certain amount of money to prevent environmental degradation. Among various valuation techniques, only the contingent valuation can measure the non-use value of ecosystem services (Mitchell & Carson, 1989), though using the method for this purpose is highly controversial because survey respondents might give biased answers (Tietenberg, 2003).[4]

Third, the indirect observable methods reveal the values of ecosystem services, based on actual market transactions of relevant services. These methods are "observable" because they use the information of both explicit market prices and trade quantities, rather than the survey results on hypothetical scenarios; in addition, the methods are "indirect" because they infer the values rather than estimate them directly. The following five techniques are often used: travel cost, hedonic value, avoidance expenditure, cost-of-illness, and cost-of-restoration/replacement.

(i) The travel cost method can value recreational resources, such as a sport fishery, by using the information on how much the visitors spend in getting to the fishing site and by estimating the demand curve from the information.

(ii) The hedonic value method, regressing the information of housing prices or wages, reveals the willingness to pay (marginal implicit price) to reduce pollution or to avoid environmental risks (e.g., exposure to a toxic substance).

(iii) The avoidance expenditure method may estimate the benefits of ecosystem quality, such as clean water, by assessing the efforts (i.e., costs) to reduce the risk of suffering environmental damages (e.g., the use of water purifiers) as well as to mitigate the impact of environmental damages (e.g., the purchase of medical treatment).

(iv) The cost-of-illness method might produce a lower bound estimate of the willingness to pay, studying both direct costs (e.g., diagnosis, treatment, rehabilitation, and accommodation) and indirect costs (e.g., forgone benefits due to the loss of work time).

(v) The cost-of-restoration/replacement may also provide a lower bound estimate of the value (ADB, 1996), based on the concept that "the economic value of providing a given quantity of a good in one way cannot exceed the cost of providing exactly the same quantity and kind of good in the cheapest alternative way" (Penning-Rowsell et al., 1992, p. 31).

Forth, the indirect hypothetical method, called contingent ranking, infers the value of environmental quality, using the data of surveys on individuals' desire for having better (or worse) environment by shouldering higher (or lower) costs. This method asks respondents to prioritise hypothetical situations where available environmental qualities differ and trade-offs exist corresponding to each quality. For example, Desvousges et al. (1983) asked the respondents to rank four cards (i.e., scenarios) according to their preferences, each of which specified a combination of the level of water quality and the amount that the respondents might be willing to pay to secure that level (e.g., boatable water for an annual payment of 50 dollars, fishable water for 100 dollars); then, the data collected from this ranking exercise helped in estimating the value of water (cited in Mitchell & Carson, 1989, p. 84).

Secondary valuation methods

The secondary methods, also known as ***benefit transfer,*** use "existing valuation information for one good or service to estimate the value of a similar good or service" (Abt Associates Inc. [AAI], 2005, p. 1-1). While the primary methods are often too expensive or time consuming, the benefit transfer requires less costs and time (U.S. EPA, 2000). This is part of the reason that this secondary approach is widely

[4] For the guidelines on designing contingent valuation studies, consult Arrow et al. (1993).

practiced (AAI, 2005). However, as Pagiola et al. (2004) point out, the benefit transfer is extremely controversial because it has often been used inappropriately. For the method to provide valid and reliable estimates, certain conditions must be met such "that the commodity or service being valued should be very similar at the site where the original estimates were made and the site where they are applied; and that the populations affected should also have very similar characteristics" (p. 22).[5] Although no systematic process for conducting the benefit transfer is currently available, the following steps might be suggested: (i) describe the ecosystem services which are under consideration to understand their characteristics; (ii) identify existing, relevant studies; (iii) review identified studies for their quality and applicability to the services; (iv) transfer the benefit estimates of reviewed, qualified studies; and (v) address uncertainties by describing their all judgments, assumptions, potential impacts on final estimates as well as other source of uncertainties inherent in the analyses (U.S. EPA, 2000, pp. 86-87).

Application of valuation methods

Different methods address different economic values. To measure the benefits of one particular ecosystem service, even several techniques may be used. Reviewing a number of studies, U.S. EPA (2000) identifies commonly-used valuation methods by type of economic values (Table 3). The report also suggests some techniques to measure the impacts on human health, amenities, and material damages.

[5] In addition to these conditions, ADB (1996) suggests to use up-to-date studies because they are likely to not only incorporate current economic conditions, but also use state-of-the-art techniques.

Table 3. Possible valuation methods to measure economic values

Benefit category	Examples of ecosystem services		Commonly-used methods
Ecological benefits			
Market: products	Provision of • Food • Fuel • Fibre	• Market • Timber • Fur, feathers	• Market
Non-market: recreation and aesthetics	Provision of • Recreational opportunities, e.g., viewing, fishing, boating, swimming, hiking • Scenic vistas		• Market (production function) • Avoidance expenditures • Hedonic values • Travel cost • Contingent valuation/ranking
Indirect: ecosystem services	• Climate moderation • Flood moderation • Groundwater recharge • Sediment trapping • Soil retention • Nutrient cycling	• Pollination by wild species • Biodiversity, genetic library • Water filtration • Soil fertilization • Pest control	• Market (production function) • Avoidance expenditures • Contingent valuation/ranking
Non-use: existence and bequest values	No associated services		• Contingent valuation/ranking

Table 3. Continued

Benefit category	Examples of ecosystem services	Commonly-used methods
Human health Mortality risks	Reduced risk of • Cancer fatality • Acute fatality	• Avoidance expenditures • Hedonic values • Contingent valuation/ranking
Morbidity risks	Reduced risk of • Cancer • Asthma • Nausea	• Avoidance expenditures • Hedonic values • Contingent valuation/ranking
Amenities	• Taste • Odour • Visibility	• Avoidance expenditures • Hedonic values • Contingent valuation/ranking
Material damage	[Damage prevention to physical structures such as buildings, bridges, and roads]	• Avoidance expenditures • Market

Source: U. S. EPA, 2000, p. 67

Although it is not conclusive, this table gives an idea of which method might be applicable to which economic value. Note that there is no clear-cut rule to suggest the use of a particular method to measure a particular value and that the secondary methods (benefit transfer) can also be applicable to many of the economic values in addition to the primary methods listed on Table 3.

2.4 Valuation process

Literature suggests possible processes for conducting economic analyses of ecosystem services (ADB, 1996; Barbier et al., 1996; Penning-Rowsell et al., 1992; TFEBPA, 1998; U.S. EPA, 2000). Although they vary slightly from each other, these processes generally include the following six steps: (i) understand physical effects on ecosystems, (ii) identify ecosystem services affected, (iii) screen the affected services, (iv) select valuation methods, (v) conduct valuation and assess net benefits, and (vi) incorporate the results into decision-making. Following the above potential process, this section describes each step in detail; see Table 4 and 5 which summarize a suggested valuation process with the case of industrial water pollution as an example.

Step 1: Understand physical effects on ecosystems

The first step of the economic analyses of ecosystem services is to understand the physical effects of environmental degradation on ecosystems. By consulting with ecologists as well as scientists in other fields and by reviewing the relevant literature, economic analysts must have basic understandings about the causes, stressors, and effects of the problems of concerned ecosystems. Suppose that the degradation of water quality is current and future environmental concerns in the marine environment. Conducting a preliminary research on the problem, the analysts might learn that the high BOD (biological oxygen demand) rates are observed and that the wastewater from local industries contributes to this degradation. The analysts may also learn that the water pollution affects the decline in fish catches.

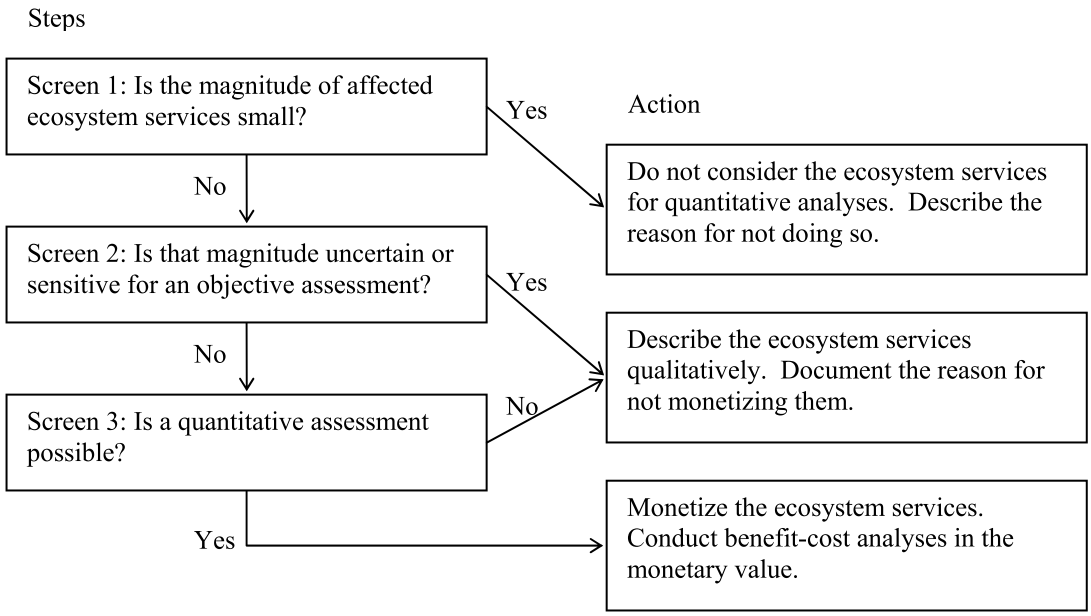
Step 2: Identify ecosystem services affected

The next step of the analyses is to identify the categories of ecosystem services which are possibly affected by the observed and/or foreseen physical effects on the ecosystems. Working closely with the experts in the field of natural science, the analysts must find the linkage between the physical impacts on the ecosystems and the impacts on the services that they provide. For example, water pollution may cause many problems such as the decline of fish catches, the loss of biodiversity, the loss of recreational opportunities, and the increase of human health risks.

Step 3: Screen the affected services

The third step is to screen the affected ecosystem services to focus on those which are most likely to affect the final results of benefit-cost assessments. This stage is necessary not only because the resources for the analyses are limited but also because not all ecosystem services can or should be monetized.

The screening may include the following three criteria: (i) Is the magnitude of affected ecosystem services small? (ii) Is that magnitude uncertain or sensitive for an objective assessment? (iii) Is a quantitative assessment possible (ADB, 1996; see Figure 4)?



Source: Adapted from ADB, 1996, p. 19

Figure 4. Screening process of affected ecosystem services

First, if the affected ecosystem services are small and unlikely to influence the direction of the net benefits of the total ecosystem services (i.e., whether the net benefits become positive or negative), eliminating these relatively minor services from the consideration for further quantitative assessments is legitimate. Second, if the effects on ecosystem services are uncertain (due to scientific uncertainty) or sensitive (due to cultural values, political considerations, and legal requirements), measuring their values in monetary terms may not be appropriate. Then, the analysts should assess the values of these services qualitatively. Third, there might not be enough data available to evaluate the ecosystem services quantitatively. Converting their values in terms of money would not be possible. At every stage of the above screening process, it is important to describe clearly the reason why certain services are excluded from the quantitative assessments.

Step 4: Select valuation methods

For the ecosystem services which remain after the screening, the next step is to choose an appropriate valuation method to measure their benefits. The possible valuation methods that are discussed in the previous section (Table 3) would be helpful for this selection procedure. In our example of water pollution case, suppose that the effect on biodiversity is difficult to estimate because significant scientific uncertainties exist and that, therefore, only fish, recreational opportunities, and human health risks are to be measured. According to Table 3, the market methods are applicable for food (e.g., fish); several methods including the travel cost method are available for recreational opportunities; and methods such as the avoidance expenditures methods are suggested for human health. After considering available data as well as resources (e.g., time, budget, and human resources) carefully, the analysts should select final methodologies.

Step 5: Conduct valuation and assess net benefits

The fifth step conducts actual valuations, using the selected methods. Assume that the analysts choose the market methods, the travel cost method, and the cost-of-illness method to measure the values of fish, recreation, and human health, respectively (Table 4). With these valuation methods (whose applications are discussed in detail in the subsequent chapter) utilized, the results may be summarized as Table 5.

Step 6: Incorporate the results into decision-making

The final step is to present the results of benefit-cost analyses properly so that the decision-makers can use the findings to address their environmental problems. U.S. EPA (2000) provides general rules for this purpose, which include the following: (i) clearly describe all important data sources and references as well as key assumptions and their justifications; (ii) explain economic models used, if any, in plain words; (iii) conduct sensitivity analyses to address uncertainties; (iv) monetize as many ecosystem services as possible under consideration; (v) highlight non-monetized and unquantified ecosystem services affected, if they are likely to influence the final results of benefit-cost analyses; and (vi) present aggregate results (i.e., the *total* net benefits of ecosystem services) and disaggregate results (i.e., the *individual* net benefits of each ecosystem services).

Table 4. Selection process of valuation methods (example)

	Steps	*1*	*2*	*3*	*4*
Causes	Stressors	Bio-physical effects on ecosystem	Ecosystem services affected	Screening results	Valuation methods
Industrial activity	BOD	Decline of fish stock	Food (fish)	√	Market
			Biodiversity	×	N/A
		Degradation of water quality	Recreation	√	Travel cost
			Human health	√	Cost-of-illness

Notes: Dashes (√) mean that the effects on ecosystem services are significant, suitable for an objective assessment, and possible to quantify; Crosses (×) mean that although their magnitudes are likely to be significant, the effects on ecosystem services are scientifically uncertain and therefore difficult to quantify.

Table 5. Benefit-cost analysis of ecosystem services (example)

Steps	*5*				
Ecosystem services	Benefits today	Benefits future without conservation efforts (1)	Benefits future with conservation efforts (2)	Increase in benefits ((2) – (1))	
Food (fish)	XXX	XXX	XXX	XXX	
Recreation	XXX	XXX	XXX	XXX	
Human health	XXX	XXX	XXX	XXX	
Total benefits	XXX	XXX	XXX	XXX	(3)
		Opportunity costs	XXX		
		Project costs	XXX		
		Total costs		XXX	(4)
		Steps 6 & 7	Net benefits	XXX	((3) – (4))

Notes: The net benefits shown in this table are likely to be underestimated because the benefits of biodiversity, which are not quantified, are not included.

3. Methodology for environmental valuation

This chapter, focusing on the environmental problems in the Yellow Sea, discusses specific theories and methodologies to evaluate the economics of conserving its vulnerable ecosystems. The ecosystem services addressed in this chapter include commercial fisheries, biodiversity, water quality, human health, and recreation/tourism. These services are considered under imminent danger. The below each section consists of the following four common components: (i) theoretical background; (ii) findings from previous studies; (iii) analytical process and techniques; and (iv) worksheets for data collection, analyses, and result presentation.

3.1 Commercial fisheries

Theoretical background

The direct use value of ecosystem services for which the market exists, such as commercial fisheries, can be measured with the market price method, specifically the production function method. This is an approach to value non-marketed environmental goods and services (e.g., seawater) which serve as inputs to produce market goods (e.g., fish) (Markandya et al., 2001, p. 154). For example, producing or catching fish (outputs) requires not only marketed services (inputs) such as labour and capital, but also non-marketed environmental services (inputs) such as water quality. Hence, the production function of fish can be expressed as follows:

$$Q = Q(X_e, X_m)$$

where Q is the amount of produced market goods (e.g., fish); X_e is the environmental services (e.g., water quality); and X_m is a vector of other inputs (e.g., labour, capital).

In theory, the value of X_e (that is, the value of the unit change of X_e) is measured by the following steps:

(i) Determine the production function of market goods (Q) as a function of environmental services (X_e) and other inputs (X_m):

$$Q = Q(X_e, X_m)$$

(ii) Estimate the change in the marketed outputs (ΔQ) due to the unit change of the environmental services (ΔX_e). The partial differentiation of Q with respect to X_e provides this estimation:

$$\Delta Q = \partial Q / \partial X_e$$

(iii) Collect the unit price of the marketed outputs: P_q (unit price of Q)

(iv) Estimate the unit price of X_e in terms of P_q. Multiplying P_q by ΔQ provides this estimation: P_e (unit price of X_e).

$$P_e = P_q \times \partial Q / \partial X_e$$

(v) Calculate the value of ΔX_e by taking ΔX_e multiplied by P_e: V_e (value of ΔX_e)

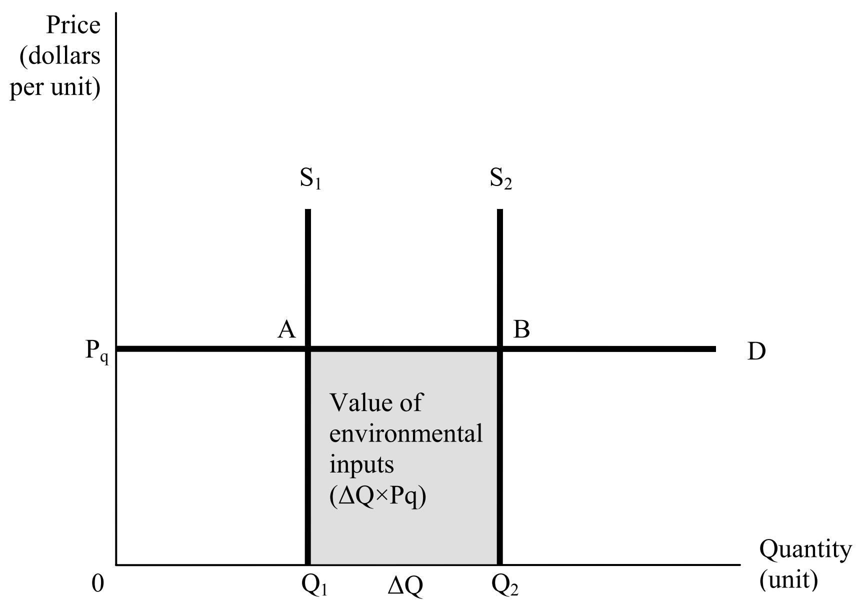
$$V_e = \Delta X_e \times P_e$$

In practice, however, estimating the value of the unit change of the environmental services (V_e) this way is challenging because of the difficulty at the second step in estimating the change in the marketed outputs due to the unit change of the environmental services (ΔQ). Therefore, the following assumptions may be made:

- The environmental improvement (e.g., better water quality) will allow producers (e.g., fishermen) to expand the outputs (e.g., landed fish) without additional cost. (This means that the marginal cost of production is zero and that the supply curve is completely inelastic.)
- The demand for the marketed outputs (e.g., fish) is infinitely elastic.
- The expected increase of the outputs due to the increase of the environmental services (e.g., water quality) is small so that the price of the outputs will remain unchanged.
- The unit price of *Q* (P_q) approximates the unit price of X_e (P_e).
- The change in the marketed outputs (ΔQ) approximates the unit change of the environmental services (ΔX_e).
- Therefore, the value of the unit change of the non-marketed inputs (V_e) is approximated by the product of ΔQ and P_q:

$$V_e = \Delta X_e \times P_e \approx \Delta Q \times P_q$$

Figure 5 illustrates the value of environmental inputs based on the above assumptions.



Source: Markandya et al., 2002, p. 337

Figure 5. Relationship of demand to economic value

D is the demand curve of the marketed outputs. S_1 and S_2 are the supply curve of the outputs *without* and *with* the unit change of the environmental services, respectively, assuming that the change of environmental services increases the outputs. The value of the change of environmental services is represented by the area ABQ_2Q_1. Note that this value is approximated, in this example, by the product of the two proxy variables: (i) the change in the marketed outputs (ΔQ) and (ii) the price of the outputs (P_q) (Markandya et al., 2002, pp. 337-338).

Findings from previous studies

Using the production function method, Sumaila et al. (2005) estimate the benefits and costs of the commercial fisheries of the Benguela Current Large Marine Ecosystem (BCLME) which covers "the continental shelf between the Angola-Benguela frontal zone in Northern/Southern Angola and the Agulhas retoflection area" (p. 13).

For the benefit estimation, the study analyzed the following six indicators: (i) landings, (ii) landed values, (iii) economic rent, (iv) exports, (v) contribution to GDP, and (vi) employment and food security. The economic rent is the surplus after deducting from landed values all the costs which are related to fishing, and is the main indicator of the benefits, that is used for the benefit-cost analysis. It is noteworthy that the BCLME study simply assumes that without the conservation of the ecosystem, the economic rent would dissipate. (The study supposes that "at the extreme, most of these values [e.g., the landed values of fish, jobs, and export revenues] can disappear if overfishing leads to the depletion of the shared fish stocks" [Sumaila et al., 2005, p. 7]). Therefore, the benefits of the conservation is as large as the economic rent which the conservation efforts prevent from being lost.

For the cost estimation, the costs of both the current and future conservation programmes are employed. These costs include the relevant administrative costs of concerned countries (Angola, Namibia, and South Africa) as well as the management costs of regional cooperation such as the operational costs of regional working groups and advisory groups. Note that the costs do not include the initial investment to provide the physical structures for the management body because it can use the existing structures of relevant programmes.

The benefit-cost analysis examined three scenarios: (i) the status quo, (ii) the establishment of an interim management body, and (iii) the establishment of a permanent management body. The second and third scenarios are *with project* options while the first scenario is a *without project* option. The study shows that the establishing the interim or permanent entity (with scenario) would produce significant benefits, R738 million [6] or R1,033 million, respectively. Meanwhile, the costs for operating these management bodies are relatively small: R78 million for the interim body and R108 million for the permanent one. Based on this analysis, the study recommends establishing the management body, though the study points out the possible difficulty to secure funds to sustain this organization.

Analytical process and techniques

To analyze the benefits and costs of commercial fisheries, the major tasks involve (i) measuring the economic rents of catching fish as the benefits of conserving them, (ii) estimating the costs of conservation efforts, and (iii) calculating the net benefits based on the above benefit and cost information; namely,

1. Collect the data on the landed values of fish over the past years, if these data are available and if the market for fish is perfect; then, skip the following second and third steps
2. Collect the data on the landings of fish over the past years, if the data on the landed values are not available and/or if the market for fish is distorted

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[6] "R" is the abbreviation for rand, the monetary unit for South Africa. One rand is about 0.15 U.S. dollars as of October, 2005 (http://wwp.greenwichmeantime.com/time-zone/africa/south-africa/currency.htm).

3. Collect the data on the market prices of fish for the same period
4. Adjust the market prices so as to eliminate the distortion (e.g., taxes, subsidies, monopoly)
5. Compute the landed values of fish by multiplying the landings by the adjusted prices (shadow prices)
6. Calculate the total annual landed values of all the fish under consideration
7. Collect the data on the annual costs of fishing efforts (e.g., boats, equipments, personnel)
8. Compute the annual economic rents of catching fish by subtracting the costs of fishing efforts (Step 7) from the total landed values of fish (Step 6)
9. Compute the average annual economic rents of catching fish
10. Collect the data on the annual costs of conservation efforts (e.g., the costs of monitoring, control, and surveillance; the relevant administrative costs of concerned countries; the operational costs of regional working groups and advisory groups)
11. Estimate the total annual costs of conservation efforts
12. Calculate the net annual benefits of conserving fish by subtracting the total average costs of conservation efforts (Step 11) from the average economic rents of catching fish (Step 9)

Figure 6 illustrates the above benefit-cost analysis of commercial fisheries.

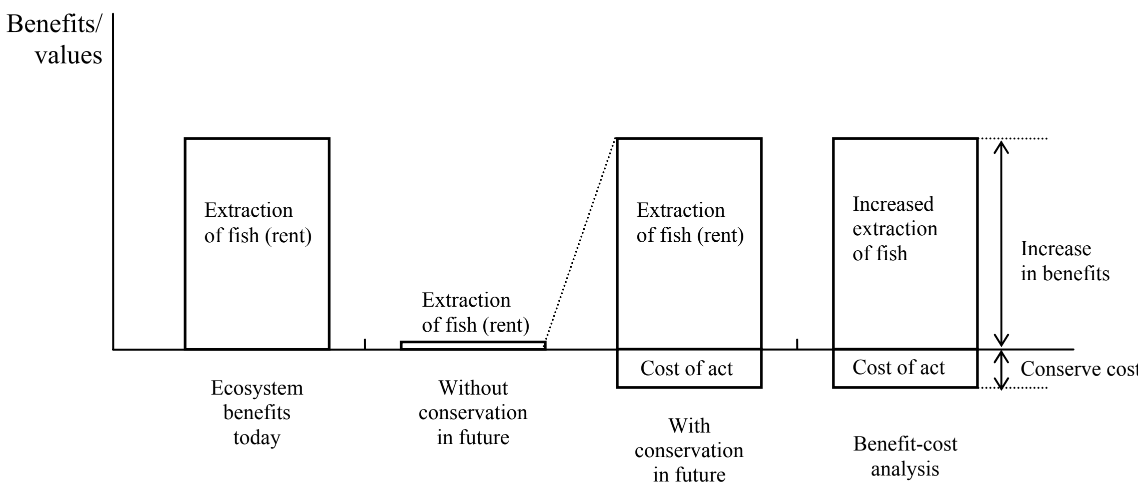

Figure 6. Benefit-cost analyses of conserving fish

Note in this figure that the benefits of conservation efforts is the economic rents of catching fish which will be realized in the future due to the conservation efforts and that the net benefits (the difference between the increased extraction of fish and the costs of conservation activities) exist. The premise of this result is that the future economic rents will dissipate without conservation.

The analysis becomes more precise by incorporating the benefits and costs accruing over time in various timings. The analytical process described above is an example of the simple two discrete terms: today and sometime in the future. However, if the benefits and costs accrue in several timings, this time factor should be considered. Assessing the net present value (NPV) of a stream of net benefits that arise over time helps in meeting this requirement. Suppose that without conservation, the benefits (economic rents of catching fish) would gradually disappear over the next 40 years. Assume also that with conservation, less yet sustainable benefits would arise for the same period (Figure 7).

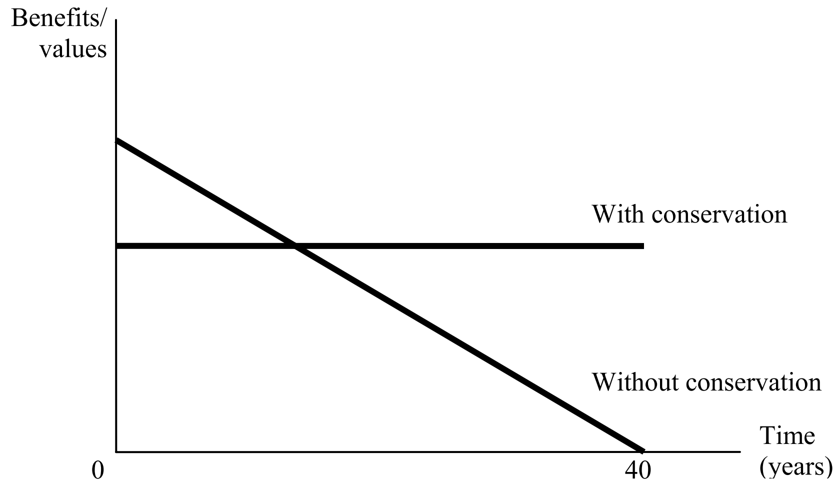

Figure 7. Benefit of catching fish with or without conservation efforts

With the cost information of conservation efforts given, the NPV of a stream of net benefits could be computed as

$$NPV[B_n] = \sum_{i=0}^{n} \frac{B_i}{(1+r)^i}$$

where r is the discount rate and B_i is the net benefits accruing in various timings. For setting the discount rate, refer to the section 2.2.

Worksheets for data collection, analyses, and result presentation

This section provides sample templates for the analyses. These eleven templates correspond to the analytical process that is described in the previous sections. Table 6 through 13 assume that both benefits and costs of conservation efforts arise simply in the two-year term. Table 14 through 16 assume that these benefits and costs accrue over time in different timings (the numbers used in the templates are fictitious for the illustrative purpose). For Table 6 up to 10, the similar format is used for different purposes. Table 6 and 7 summarize the collected market data on the landed values and market prices of fish by species, respectively. Table 8 presents the adjusted prices of fish, if the distortion exists in the market. Table 9 shows the landed values of fish based on the information from Table 6 and 8. Table 10 consists of the costs of fishing efforts (e.g., fishing boats, equipments, personnel) by species. Table 11 summarises the economic rents of fishing based on the information of Table 9 and 10. Table 12 provides the estimated costs of conservation efforts. Table 13 summarises the result of the benefit-cost analysis of conserving fish for the two-year term. Table 14 and 15 show the benefits of fishing for the 40-year term without or with conservation activities, respectively. Table 16 presents a stream of the net benefits and NPV of conservation efforts based on the information from Table 14 and 15.

Table 6. Landings of fish

	Year				Unit: tones
Species	1	2	3	4	5
A	XXX	XXX	XXX	XXX	XXX
B	XXX	XXX	XXX	XXX	XXX
C	XXX	XXX	XXX	XXX	XXX
D	XXX	XXX	XXX	XXX	XXX

Source:

Table 7. Market prices of fish

	Year				Unit: $million
Species	1	2	3	4	5
A	XXX	XXX	XXX	XXX	XXX
B	XXX	XXX	XXX	XXX	XXX
C	XXX	XXX	XXX	XXX	XXX
D	XXX	XXX	XXX	XXX	XXX

Source:

Table 8. Adjusted prices of fish

Unit: $million

Species	Year 1	2	3	4	5
A	XXX	XXX	XXX	XXX	XXX
B	XXX	XXX	XXX	XXX	XXX
C	XXX	XXX	XXX	XXX	XXX
D	XXX	XXX	XXX	XXX	XXX

Source:

Table 9. Landed values of fish (Table 6 x 8)

Unit: $million

Species	Year 1	2	3	4	5
A	XXX	XXX	XXX	XXX	XXX
B	XXX	XXX	XXX	XXX	XXX
C	XXX	XXX	XXX	XXX	XXX
D	XXX	XXX	XXX	XXX	XXX

Table 10. Costs of fishing efforts

Unit: $million

Species	Year 1	2	3	4	5
A	XXX	XXX	XXX	XXX	XXX
B	XXX	XXX	XXX	XXX	XXX
C	XXX	XXX	XXX	XXX	XXX
D	XXX	XXX	XXX	XXX	XXX

Source:

Table 11. Economic rents of catching fish (Table 9 − 10)

Unit: $million

Species	Year 1	2	3	4	5
A	XXX	XXX	XXX	XXX	XXX
B	XXX	XXX	XXX	XXX	XXX
C	XXX	XXX	XXX	XXX	XXX
D	XXX	XXX	XXX	XXX	XXX
Total	XXX	XXX	XXX	XXX	XXX

Average XXX (1)

Source:

Table 12. Costs of conserving fish

Conservation efforts	Unit: $million	
Monitoring	XXX	
Control	XXX	
Surveillance	XXX	
National administrative costs	XXX	
Regional working groups	XXX	
Regional advisory groups	XXX	
Total	XXX	(2)

Source:

Table 13. Benefit-cost analysis of conserving fish (in the two-year term)

	Unit: $million	
Benefits (economic rents)	XXX	(1)
Costs	XXX	(2)
Net benefits	XXX	(1) − (2)

Table 14. Benefits of catching fish without conservation

Year	Species A	B	C	D	Unit: $million Total
1	40	20	20	20	100
2	39	19	19	18	95
3	38	18	18	16	90
..	..	..	..	..	..
..	..	..	..	..	..
..	..	..	..	..	..
40	0	0	0	0	0

Source:

Table 15. Benefits of catching fish with conservation

Year	Species A	B	C	D	Unit: $million Total
1	20	10	10	10	70
2	20	10	10	10	70
3	20	10	10	10	70
..	..	..	..	..	..
..	..	..	..	..	..
..	..	..	..	..	..
40	20	10	10	10	70

Source:

Table 16. Benefit-cost analysis of conserving fish (in the 40-year term)

Unit: $million

Year	Cost	Incremental benefits	Net benefits Total
1	7	-30	-37
2	7	-25	-32
3	7	-20	-27
..	..	..	..
..	..	..	..
..	..	..	..
40	7	70	63
		NPV	XXX

Source:

3.2 Biodiversity

3.3 Water quality

3.4 Mariculture

3.5 Human health

3.6 HAB

3.7 Recreation/tourism

3.8 Coastal infrastructure

4. Conclusions

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Annex I

Draft Execution Plan of Environmental Valuation

1 Objectives

The objectives of the Environmental Valuation are to understand the ecosystem benefits provided by Yellow Sea and the costs of conservation efforts.

The results of the Analysis will be used as inputs for the Transboundary Diagnostic Analysis/Strategic Action Programme development.

2 Activities

To achieve the above objectives, the Environmental Valuation studies will be implemented. For detailed information about these analytical works, consult the "Provisional Guideline for Environmental Valuation."

2 Expected outcomes

The expected outcomes of the analysis include the information on:

- Established conceptual framework for Environmental Valuation
- Current value of Yellow Sea
- The benefits and costs of Yellow Sea with and without conservation efforts
- Policy implications for the sustainability of Yellow Sea

3 Implementation structure

The implementation structure for the Environmental Valuation consists of four major entities: (i) Regional Working Group-Investment (RWG-I), (ii) RWGs for other components, (iii) Project Management Office (PMO), and (iv) Economists/Consultants.

Collection and analysis of data will be conducted by independent experts/consultants who have not only the expertise and experiences in the relevant field but also the local knowledge and perception.

The PMO will supervise the work conducted by the consultants, with technical guidance from RWG-I members in order to incorporate the regional dimension into the analysis and to use its results effectively for the TDA/SAP development.

The PMO will also coordinate overall activities and provide logistical assistances for the consultants.

The RWGs for other components will provide the consultants with data from their respective component's data and information collection activity, as well as the preliminary interpretation of the data.

The figure below summarises the implementation mechanism.

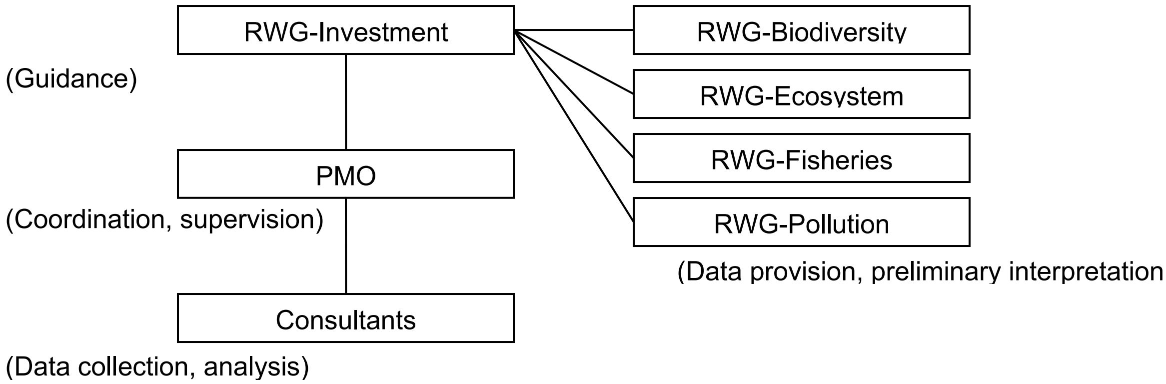

Figure. Implementation Structure of Environmental Valuation

4 Work schedule

Phase I of this work will be carried out from January 2006 through August 2006. The final report will be submitted to and discussed at the 3rd RWG-I meeting. The work schedule of Phase II of this work will be discussed in the 3rd RWG-I meeting.

Implementation steps for Phase I	Time frame
1. Finalisation of theoretical framework	End of December 2005
2. Identify the targeted groups	November/December 2005
3. Identify the process for the targeted groups	February 2006
4. Prepare the methodology for the targeted groups	March 2006
5. Case study	July 2006
6. Repeat steps 3 and 4	August 2006