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# Using economic values to evaluate management options for fish biodiversity in the Sikakap Strait, Indonesia

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**Abstract.** *Rizal A, Dewanti LP. 2017. Using economic values to evaluate management options for fish biodiversity in the Sikakap Strait, Indonesia. Biodiversitas 18: 575-581.* The unavailability of total economic values of fish biodiversity in Sikakap Strait, Mentawai District of West Sumatra, Indonesia both in the short and long term, has created the rejection of their existences in the coastal area. The purpose of this study was to estimate the total economic value of fish biodiversity in Sikakap Strait, West Sumatra using total economic value concepts. The fish biodiversity's total economic value is expressed by estimating the use value, indirect use value and non-use value. The study used benefit transfer and survey methods using secondary data to estimate the total economic value of fish biodiversity. The total economic value of the fish biodiversity of USD 745,602 per year was calculated by summing the direct use value (USD 4,262,884 per year), indirect use value (USD 24,560 per year), and non-use value (USD 575 per year). The research hypothesis that the fish biodiversity's sustainable resource management has economic value is supported. These values help to make decisions about allocating resources between competing uses.

**Keywords:** economic valuation, fish biodiversity, Sikakap Strait

## INTRODUCTION

The coastal and marine sector in the current assessment is taken to mean the 'coastal zone' defined by the United Nations Environment Programme (UNEP) as 'the area of land subject to marine influences and the area of the sea subject to land influences'. The coastal is the place where sea and land meet. Geographers, geologists and biologists unanimously acknowledge the unique properties of coastal zones as the contact zone between the lithosphere and the hydrosphere. This interface is represented on geographic maps as a thin *coastline* (Pendleton 2008; Payne and Sand 2011).

Coastal areas are typically shared by many user groups or activities which conflict of access to the resource may arise. Such a conflict may arise, for example, due to competing uses between small-scale and commercial fishermen (Rizal et al. 2001), competing uses of fish stock exploited by different actors and institutions or simply conflicting over a narrow area of the strait for different purpose of coastal activities such as local fishermen and outsider fishermen.

Although the importance of coastal ecosystems to human society has many dimensions (ecological, socio-cultural and economic), expressing the value of ecosystem services in monetary units is an important tool to raise awareness and convey the (relative) importance of ecosystems and biodiversity to policy makers. Information on monetary values enables more efficient use of limited funds through identifying where protection and restoration is economically most important and can be provided at lowest cost (Crossman and Bryan 2009; Crossman et al. 2011). It can also assist the determination of the extent to which compensation should be paid for the loss of ecosystem services in liability regimes (Payne and Sand 2011). These phenomena, coupled with the lack of administrative resources, make the management of coastal resources, especially fishery resources, where livelihood of small-scale fishermen depends very much on fishing, is indeed a challenging task.

In West Sumatra, this challenging task is amplified by the complexity, uncertainty and rent seeking behavior which arises in the era of decentralization. Since alteration of regional authority law (from law number 32/2009 to 23/2014), when the decentralization process shifted to provincial authority from district authority, they seek various ways to manage their own fisheries, to increase provincial government revenue (known as PAD, an abbreviation of *Pendapatan Asli Daerah* or Original Regional Revenue.

Mentawai island's fish resources play an important role in the economy of West Sumatra, particularly, fish biodiversity of sikakap strait. The contribution of Sikakap Strait related activities was estimated to be dominant of the West Sumatra's Fish Production (Fisheries Official of Mentawai District 2015). The fish biodiversity provides an important source of income and employment for those living in coastal and rural areas of Mentawai Island. In addition, the fish biodiversity has been a critical source of affordable animal protein for the majority of coastal inhabitants.

Scientists argue that a long term value of fish biodiversity is greater than its value for any other use. Therefore, careful management of this resources provides numerous benefits to a variety of users. Government provides maximizing producers and utility maximizing consumers in traditional markets should allocate scarce fish resources and environmental uses in an economically efficient manner. The information from resource valuation will help guide decision makers to more objectively consider management options in allocating scarce fish resources efficiently.

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This paper describes the context in which development of marine fisheries in Mentawai islands took place, and provides an assessment of the largely favorable effect of the economic valuation of Sikakap Strait's Fish biodiversity. The paper concludes by examining the concept of cost-benefit analysis in comparing each management option. It was in reference to the concept that the local government rationalized the the fish biodiversity management.

## MATERIALS AND METHODS

### Study area

Sikakap Strait, located in the Mentawai Islands, is one of the important straits in the Sumatra's island of Pagai island. Sikakap Strait has separated two islands, they are North Pagai and South Pagai (Fig. 1). As an administrative boundary, Sikakap Strait is part of Sikakap subdistrict. Concerning the climate patterns which exist in Indonesia, Sikakap Strait particularly is affected by the global phenomenon of dipole mode that stimulates Moson and inter-tropical Convergence. Western southeast wind circulation will stimulate a dry season which takes place in May-October, and the circulation of winds moving towards the northwest will result in the rainy season from November to March.

Rainfall is ranging between 2500 - 4700 mm / year with the number of rainy days between 132-267 days of rain per year. Differences that exist at the moment in both wet and dry is not clearly visible, due to heavy rain with short duration may occur in the dry season or during the transitional season. This happens suspected because of the wind storm of Indian Ocean (*Samudera Hindia*) blowing towards the mainland of Sumatra. The area of Sikakap Strait is 3,960 hectares with the coast length 19.79 kilometers (km). The Strait is located at the latitude and longitude coordinates of -2.8 and 100.2. For Fishing enthusiasts, Sikakap Strait could be one of the best fishing or outdoors adventure location in the regions of West Sumatra. Data published by Fisheries Official of Mentawai District (2015) indicate that there are fifteen fish species in Sikakap Strait which divided into two groups.


**Figure 1.** Location of Sikakap Strait, Mentawai, West Sumatra, Indonesia

**Table 1.** Pelagic fish production in Sikakap Strait, Mentawai, West Sumatra, Indonesia

| Fish species | | | Production (ton) | Value (US$) |
|---|---|---|---|---|
| **English name** | **Indonesian name** | **Scientific name** | | |
| Pickhandle barracuda | Baracuang | *Sphyraena jello* | 250 | 144,231 |
| Barred fish | Tenggiri | *Scomberromo commersoni* | 8 | 4,615 |
| Skipjack tuna | Tuna | *Euthynnus affinis* | 600 | 692,308 |
| Anchovy | Teri | *Stolephorus commersonii* | 8 | 4,615 |
| Sardine | Sardin | *Sardinella sirin* | 380 | 219,231 |
| Long jawed mackerel | Kembung | *Rastrelliger kanagurta* | 516 | 297,692 |
| Trevally fish | Selar | *Selaroides leptolepis* | 502 | 289,615 |
| Sailfish | Layaran | *Istiophorus platypterus* | 85 | 49,038 |
| Total | | | 2,349 | 1,701,345 |

Source: Fisheries Official of Mentawai District (2015)

**Table 2**. Demersal fish production in Sikakap Strait, Mentawai, West Sumatra, Indonesia

| Fish species | | | Production (ton) | Value (US$) |
|---|---|---|---|---|
| **English name** | **Indonesian name** | **Scientific name** | | |
| Grouper | Kerapu | *Epinephelus fuscoguttatus* | 1,182 | 1,363,846 |
| Yellow snapper | Kakap kuning | *Lutjanus kasmira* | 500 | 576,923 |
| Grey snapper | Jenihin | *Symphorichthys spirulus* | 155 | 89,423 |
| Red snapper | Kakap Merah | *Lutjanus. campechanus* | 419 | 483,462 |
| Stingray | Pari | *Mobula mobular* | 2 | 1,154 |
| Pony Fishes | Peperek | *Leiognathus dussummieri* | 81 | 46,731 |
| Total | | | 2,339 | 2,561,539 |

Source: Fisheries Official of Mentawai District (2015)

**Pelagic fish**

Pelagic fish are the types of fish that their lives were in the seawater. This fish has a slender body shape in order to facilitate the movement against the sea water current. Pelagic fish in the sea waters of the Strait of Sikakap most diverse. Table 1 describes detail of Pelagic fish production.

Based on Table 1 pelagic fish species that dominate in Sikakap Strait is Skipjack tuna as 600 tons, and then Long jawed mackerel amounted to 516 tons, 502 tons of trevally fish and fish barracuda amounted to 250 tons. The value of production of fish commodities because these fish have quite high economic value, especially tuna species.

**Demersal fish**

Demersal fish are the kinds of fish that their lives were on the bottom, such as coral reefs and sandy substrate. The demersal fish are fish that are caught with basic fishing gear such as bottom trawls (bottom trawl), basis of gill nets (bottom gillnet), longlines base (bottom long line), traps and others. Demersal fish production can be seen in Table 2.

Following Table 2, the dominating demersal fish in the Sikakap Strait as 1,182 tons of grouper and yellow snapper as much as 500 tons, 429 tons of red snapper and gray snapper (jenihin) as 155 tons. Based on the number of grouper production for one year, it can be seen that the potential demersal fish is grouper fish in Sikakap Strait, it could become one of the economic drivers for coastal communities.

**Procedures**

There are basically two broad approaches to valuation, each comprising a number of techniques. These are the direct and indirect approaches. The direct approach looks at techniques which attempt to elicit preferences directly through the use of survey and experimental techniques, such as contingent valuation and contingent ranking methods. People are asked directly to state or reveal their strength of preference for a proposed resource. In contrast, the indirect approach is a technique which seeks to elicit preferences from actual, observed market-based information.

Most of the studies have been done in Indonesia using total economic value. The total economic value of a resource can be disaggregated in two components which are use value (UV) and non use value (NUV). Use value includes direct use value (DUV), indirect use value (IUV) and option value (OV). Nonuse value, on the other hand, has proved to be both difficult to define and measure. Nonuse value can be subdivided into existence value (XV) which measures willingness to pay for some moral, altruistic or other reason and unrelated to use or option value and bequest value (BV) which measure an individual willingness to pay to ensure that his/her heirs will use the resource in the future. The total economic value can be expressed by:

$$TEV = UV + NUV = (DUV + IUV + OV) + (XV + BV)$$

The economic valuation of fish biodiversity can be carried out through two stages:

*Identification stage*

This is an important stage to know the benefits and ecosystem services of fish biodiversity, especially the function in relationship with the other components in an ecosystem. The identified benefit include:

*Use value (UV).* UV consists of two kinds of value, viz. (i) Direct use value (DUV)**.** This is defined as use which is directly obtained from utilizing fish biodiversity, such as the use of fish for food consumption, commercial and fishing, etc. The total direct use from fish biodiversity can be formulated in a simple equation: Direct use (fish biodiversity) = food consumption use + commercial use + fishing, etc. (ii) *Indirect use value (IUV)****.*** An indirect use is defined as use which is indirectly derived from fish biodiversity such as tourism, education, and research.

*Non Use Value (NUV).* NUV consists of three kinds of value, viz. (i) *Option value (OV).* The concept of option value can be interpreted as the potential future direct and indirect uses of fish biodiversity. If the uncertainty regarding future use is measurable in the form of probability for a certain outcome, the option value can be interpreted as the risk premium paid to avoid the outcome of reversible destruction. In other words, the individual is willing to pay an amount in addition to the actual price today in order to keep the use option for later. Therefore, total use value can be defined as the sum of current total direct and indirect use values and this risk premium. (ii) *Existence value (EV).* An existence value is interpreted as a value humans gain from simply knowing that an ecosystem or species exists, independent of weather an individual uses it or not. The existence value of fish biodiversity can be approached by using the contingent valuation method through a survey of selected respondents. (iii) *Bequest Value.* A bequest value is related to preserving the fish biodiversity heritage for the coming generations. Its value is derived today from knowing that the fish biodiversity heritage will exist and will be used by the future generation.

Based on the above, the total economic value (TEV) is a sum of direct use value (DUV), indirect use value (IUV), and Non Use Value (NUV) has three components viz: option value (OV), existence value (EV) and bequest value (BV).

*Quantification stage*

A quantification stage is the accounting of the total use and function of an ecosystem in monetary terms. There are a lot of quantification methods which are often used, some of which are: (i) *Market price.* The market price approach is used to account for a marketable component of fish biodiversity, such as food consumption and commercial fish from a restaurant or aquarium. The approach is used to value a direct use. (ii) *Indirect price.* An indirect price can be used to account for the non-marketable component of fish biodiversity. This method is very suitable to valuate a physical and biological use. (iii) *Contingent valuation method.* Contingent valuation method is a very popular approach which is most used in valuating an environmental component, especially for a non-marketable one. In general, this method is carried out through a survey by asking the selected respondents about the existence of a certain component of fish biodiversity.

CVM can be used to estimate both use and non-use values, and it is the most widely used method for estimating non-use values. It is also the most controversial of the non-market valuation methods. It is called “contingent” valuation, because people are asked to state their willingness to pay, *contingent* on a specific hypothetical scenario and description of the environmental service (Jakobsson and Dragun 2001). This method generally involves a survey of a sample of people on the amount they would be willing to pay for some aspect of biodiversity to be improved or conserved.

Strengths of The Contingent Valuation Method (CVM) is an increasingly popular method for valuing biodiversity. It has more potential for capturing biodiversity’s more abstract benefits than revealed preference techniques. It is flexible and works best when estimating values for goods and services that are easily identified and understood by users (Jakobsson and Dragun 2001). The nature of CVM studies and the results of CVM studies are not difficult to analyze and describe.

Weaknesses of The following areas have made CVM a controversial approach. However, as the method continues to be applied these issues are being ironed out (Bateman and Turner 1993; Jakobsson and Dragun 2001): (i) Asking people their willingness to pay (WTP) to maintain an element of biodiversity elicits very different responses to those found when Willingness to Accept (WTA) questions are asked. WTA significantly exceeds WTP. Critics have claimed that this invalidates the CVM approach, showing responses to be expressions of what individuals would like to have happened rather than true valuations. However, recent research in behavioral economics has shown that even in market contexts people are less willing to lose a certain dollar amount compared to gaining the same amount when structured scenarios are put to them. (ii) CVM is prone to a range of potential biases, such as when the respondent provides a biased answer to influence the policy outcome or when respondents are forced to value attributes with which they have little or no subject experience. However, these are not insurmountable problems and the use of experimental economics to review strategic behavior incentives has untapped potential. (ii) The payment vehicle chosen eg, taxes or a donation, may impact on WTP and cause the valuation to be an inaccurate expression of the actual value of biodiversity. (iv) External validation of the method's results is difficult and hence the method's credibility suffers. (v) Expensive and time-consuming because of the extensive pre-testing and survey work.

In This research, the contingent valuation method was used to explore people's willingness to pay for two aspects of biodiversity: all endangered species of flora and fauna in Sikakap Strait, The study was motivated by a legislative requirement to include social and economic valuation in species and biodiversity conservation policy decision making in Sikakap strait. Two questionnaires were circulated amongst a random sample of 209 inhabitants of Sikakap subdistrict, One questionnaire asked how much people were prepared to pay for the conservation of fish species and the other for the conservation of fish biodiversity, People were asked how much they would be willing to pay a year to conserve these two aspects, The payment vehicle was an increase in local government taxes and/or a donation to a private conservation organisation.

**Data analysis**

The economic value of fish biodiversity can be viewed from its functions which are social, ecological, physical and biological aspects. These functions are classified to their uses, namely direct use value (DUV), indirect use value (IUV), option value (OV) and existence value (EV).

The data source of Table 3 becomes a point of reference of benefit transfer analysis. Although there have been varying classifications of benefit transfer methods, in this research, the author, used unit value transfer approach. Unit value transfers can perform satisfactorily if the study and policy contexts are very similar (Morrison and Bennett 2004: Bateman et al. 2011). Unit value transfers involve the transfer of a single number or set of numbers from preexisting primary studies. Unit values can be transferred "as is" or adjusted using a variety of different approaches (e.g., for differences in income or purchasing power, or according to expert opinion).

The benefits transfer method is not a specific valuation approach. Rather, it involves estimated values for biodiversity or ecosystem services being 'transferred' from studies carried out elsewhere. For example, values for recreational fishing in one state can be estimated by applying estimates of recreational fishing values calculated for another state. Benefit transfer is a convenient method to use when it is too expensive or time-consuming to conduct a new valuation study. While there are limitations in using benefits transfer to derive a precise dollar value for impacts, it can provide an indication of the likely magnitude of environmental values.

However, benefit transfers are only as accurate as the initial study and if conditions are similar at both sites. In addition, care should be taken when extrapolating value estimates from one site or population to another. One of its uses is as a resource for benefit transfer, but as noted above it is only valid if the conditions and environmental change being proposed are similar (Morrison and Bennett 2004).

## RESULTS AND DISCUSSION

**Results**

The benefit of fish biodiversity per year in Sikakap Strait can be value as follows: (i) *Direct use value.* There are 14 species productive identified for fishing catch uses for the fish biodiversity in Sikakap Strait varying from Pelagic fish and demersal fish such as Pickhandle barracuda (*Sphyraena jello*), anchovy *(Stolephorus commersonii)*, red snapper *(Lutjanus Campechanus)* and other species. The economic value of this direct use value as US $ 4,262,884. (ii) *Indirect use value.* Three indirect use values are considered, varying from fishing tourism, education and research with economic value as US $ 24,560. (iii) *Option Value.* Biodiversity has been selected to refer the different types of biological diversity habitats or traits which exist in any given system. The biodiversity value is US $ 15. (iv) Existence value. Existence value is interpreted as value inhabitants of Sikakap subdistrict gain from simply knowing that fish biodiversity exists, independent of whether an individual uses it or not. By using the contingent valuation method, the average of 209 inhabitants of Sikakap subdistrict valuates the fish biodiversity as US $ 560. The cost of utilizing the fish biodiversity are US $ 1,866,809 (Rizal 2016). Therefore the Total Economic Value of fish biodiversity is US $ 745,602 per year (Rizal 2016).

In order to select the best management option for achieving sustainable fish biodiversity management, some studies have been done by Ruitenbeek (1992), Stevens et al. (1995), Oglethorpe and Miliadou (2000), and Rizal et al. (2001). These studies used Cost-benefit analysis in comparing each management option. The cost-benefit analysis aimed at assisting the decision-maker to make a decision which is consistent with efficiency in the allocation of resources in a certain area. Benefit and cost of proposed management option in the fish biodiversity were calculated as follows.

$$\text{Net Present Value (NPV)} = \sum_{t-i}^{n}\left(B_t - C_t\right)/\left(1+r\right)^t$$

Where:
Bt = Benefit from utilizing fish biodiversity
Ct = Cost of utilizing fish biodiversity
t = Time horizon (10 years)
r = Discount rate (12,5 %)

**Table 3**. Economic benefit of Sikakap Strait's fish biodiversity, Mentawai, West Sumatra, Indonesia

| Type of benefit | Benefit /year (US$) | Derived from | Data source |
|---|---|---|---|
| DUV | $ 4,262,884 | Total value of 14 fishes species production | Fisheries Official of Mentawai District (2015) |
| IUV | $ 24,560 | Total Net Revenue of tourism, education, and research activities | Rizal (2016) |
| OV | $ 15 | Types of biological diversity habitats or traits which exist in any given system | Riutenbeek (1992) |
| EV | $ 560 | The contingent valuation method, the average communities valuate the fish biodiversity | Rizal (2016) |

Note: The value was adjusted to the current currency conversion and this benefit is attributed to the tax levied by the local government from the fishery

The selection of the best management option was based on the highest value of NPV. The procedure for selecting management options will often rely on some judgment about technical and economic feasibility. Using scenarios, the fish biodiversity management options selected are restricted area management, quota fishing, and fishing gear management. Using the benefit-cost analysis framework, the analysis showed that by restriction area strategy for fish biodiversity resulted in lower NPV (US $ 10,347) compared to sustainable fishing gear management (US $ 11,043). The management option for quota fishing resulted in a higher NPV (US $ 15,195) compared to sustainable fishing gear management (Rizal 2016).

A longstanding theoretical paradigm suggests that species diversity is important because it enhances the productivity and stability of ecosystems (Odum 1950). The management option in Sikakap Strait represents an important turning point for the fish biodiversity management strategy. The fish biodiversity management options have been confirmed in a manner consistent both with sound biological management and with important social goals of improving incomes and employment opportunities for the majority of those involved in the fisheries sector. Elsewhere in West Sumatra, fish biodiversity management continues to be the single most important issue faced by those responsible for establishing fisheries management and development policies.

**Discussion**

Expressing ecosystem service values in monetary units also provides guidance in understanding user preferences and the relative value current generations place on ecosystem services. These values help to make decisions about allocating resources between competing uses whereby it should be realized that monetary values that are based on market prices only, usually neglect the rights (values) of future generations (Farley 2008).

Furthermore, the measurement of the broad range of ecosystem service flows and their values in monetary units or otherwise is a fundamental step to improve incentives and generate expenditures needed for their conservation and sustainable use, such as systems of Payments or Rewards for Ecological Services (Farley and Costanza 2010; Leimona 2011).

In the foreseeable future, it is unlikely that the common resources, particularly fish biodiversity, will achieve widespread acceptance for the management of fisheries resources in Mentawai island. The open access fisheries have proven both biologically and socially unworkable due to increased pressure on the resource caused by population growth, technological innovation, and new marketing opportunities. As fish biodiversity's stocks are threatened. by depletion, there arises the need to impose some controls on open access fisheries.

Regardless fish biodiversity management entails allocational decisions which are inherently political. Powerful economic interests often are able to influence political processes to their advantage. The concept of fish biodiversity management introduces a countervailing perspective on resource allocation based on longterm usage. In the context of Indonesian fisheries, fish biodiversity management pertains to lessen overfishing and lead to recognition of responsible fisheries as important considerations in resource management. The awareness of the uses and functions of fish biodiversity can be viewed by knowing its functions for enhancing the productivity and stability of strait ecosystems.

At first sight, the resulting monetary value estimates seem to give unequivocal support to the belief that biodiversity has a significant, positive social value. Sikakap Strait's fish biodiversity plays an important role for the livelihood of small-scale fishermen whose life dependent upon fishing and marine related activities around the strait. However, given a high potential economic value that could have been generated from other activities and the need to protect the strait from over-exploitation, there should be a trade-off between protecting the right of the fishermen to fish in the strait and allowing the government to establish fish biodiversity management strategy. It is worth noting, however, that the economic benefits derived above should be interpreted with caution. The economic benefits secured could be higher or even lower than the figures above due to the following reasons. First, the benefits do not include the non-use values of the resources derived from Sikakap Strait's fish biodiversity, since no appropriate economic valuation had been applied for the area so far. Second, as acknowledged by Riutenbeek (1992), the value is only an approximation (rough estimates) since no data available for detail calculation. For example, one has to estimate demand function for the goods and services derived from Sikakap Strait's fish biodiversity to include the benefits secured by consumers as a whole. To do this analysis, however, it requires a complete panel data, which is not easily available. Third, the benefits must be weighted against resource degradation which has been occurring in the Sikakap Strait's fish biodiversity.

To secure the benefits from Sikakap Strait's fish biodiversity, however, is not at costs. The local as well as national government has spent a substantial amount of funding to ensure better implementation of fisheries management in Sikakap Strait. At the micro level, it would require substantial management and rehabilitation costs to achieve healthy Sikakap Strait's fish biodiversity, so that the potential economic benefits described above could be sustained.

It is also worth mentioning that continuing dialogue with all stakeholders of the Sikakap Strait would improve the outcomes. The dialogue, however, should be facilitated by the third-party since lack of trust to the local government would not ensure smooth dialogue to solve the conflict in the strait.

Therefore, it is important to value the fish biodiversity before deciding a development program, since in addition to the market value, the resource has attributed to many uses and function which is not marketed. Management of fish ecosystems should address that the resources are not only valued in terms productive capacity but the total functions of fish biodiversity. The incorporation of market and non market value of the fish biodiversity in selecting the best management options will result in an efficient allocation of resource and the sustainability of fish biodiversity.

Values in monetary units will never in themselves provide easy answers to difficult decisions, and should always be seen as additional information, complementing quantitative and qualitative assessments, to help decision makers by giving approximations of the value of ecosystem services involved in the trade-off analysis. However, even if we do not have a 'precise' value for, for example, Types of biological diversity habitats we can assess broadly how valuable it is as an ecosystem service relative to other services, or the costs of the absence of that service, in a particular decision-making situation.

Note that expressing values in monetary units can be a time and resource intensive exercise and often quantitative insights expressed in bio-physical units are sufficient to communicate benefits (e.g. number of people benefitting from fish biodiversity). Valuation should therefore only be done where it is needed. However, we believe that in almost all decision-making situations trade-offs are involved and some form of valuation is needed.

Better knowledge about the monetary value of ecosystem services communicates important information to complement quantitative and qualitative insights and can help to make the positive and negative externalities of changes in ecosystems visible and eventually internalize at least part of their true economic and social importance in decision making, economic accounting and policy response.

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