Economic Valuation Strategies for Instream Flows: Review and Recommendation

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For

Friends of the San Francisco Estuary

August 2016

Executive Summary

In addition to providing drinking water for people, livestock, and crops, freshwater flows are known to be a "master driver" or "master variable" in shaping the biological processes of freshwater and estuarine ecosystems, including the San Francisco Bay-Delta Estuary. The negative impacts of reduced drinking water supply are often phrased in financial terms, but the economic benefits of freshwater flows in preserving and restoring the ecosystems and associated services of the Bay-Delta Estuary have not received as much attention.

Economic valuations of natural resources serve to put ecosystem benefits in human, monetary terms, and have become increasingly common in recent decades. While Friends of the San Francisco Estuary (Friends) acknowledges the bias and limitations of placing human value on these natural resources, Friends believes that an economic valuation of benefits provided by freshwater flows is necessary to inform policy decisions regarding flows. This literature review finds that the most effective economic valuation strategy for instream flows is a contingent valuation study—an economic technique where respondents are surveyed to assess the value they place on an ecosystem and the human benefits it provides.

I. Introduction

Freshwater flows are a "master driver" in the San Francisco Estuary; these flows are critical to the ecology the estuary, and the Water Board acknowledges their necessity for beneficial uses such as fish, wildlife, and recreation. Despite the importance scientists have assigned to instream flows, their economic value to Californians is overlooked in economic analyses.

While the value of water for urban and agricultural uses is easily computed with market prices[1], the economic value of instream flows is not so transparent. Urban and agricultural valuations of water fail to account for the replacement costs of finding that water elsewhere, or the opportunity costs of instream beneficial uses foregone when water is withdrawn (Loomis 1998). Pegging water's value at its historical cost and ignoring the dynamics of replacement and opportunity costs causes the resource to be underpriced; as a result, demand for its extraction increases.

Freshwater flows are critical to the delta's ecosystem and human inhabitants: these flows maintain critical habitat, support populations of endangered and threatened fish, bolster commercial fisheries, increase recreation activity, protect in-Delta agriculture, and help avoid desalination costs for urban users. By determining the value of freshwater flows, Friends of the San Francisco Estuary hopes to call attention to the benefits these flows offer the California economy, despite their absence from traditional markets.

The purpose of this literature review is to provide a background in valuation approaches that have been taken with instream flows in the past, with an emphasis on estuarine systems, as well as recommend an approach for a future valuation study.

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[1] While it is true that water for agricultural and urban uses has a market price, these uses often underprice water; market price does not necessarily reflect the true value of water to these users (Buck et al. 2014, Teodoro 2005).

II. Valuing Environmental Services

A. Categories of Value

The value of ecological goods and services is divided into two broad categories: use values and non-use values. Together, these categories comprise Total Economic Value.

Use values are split into direct use (further subdivided into consumptive and non-consumptive direct use) and indirect use (comprising benefits that accrue to humans due to the natural processes performed by ecosystems, such as sediment transport performed by freshwater flows).

Non-use values comprise bequest value and existence value. Bequest value is the value individuals derive from knowing that future generations will benefit from a resource, whereas existence values are the values derived from knowing a resource exists, even if the individual never engages with the resource directly. Economists debate the categorization of option value--the value of having the option to use a resource in the future--considered alternately a use value and a non-use value. Figure A, from The Economics of Ecosystems and Biodiversity (TEEB), illustrates these categories.

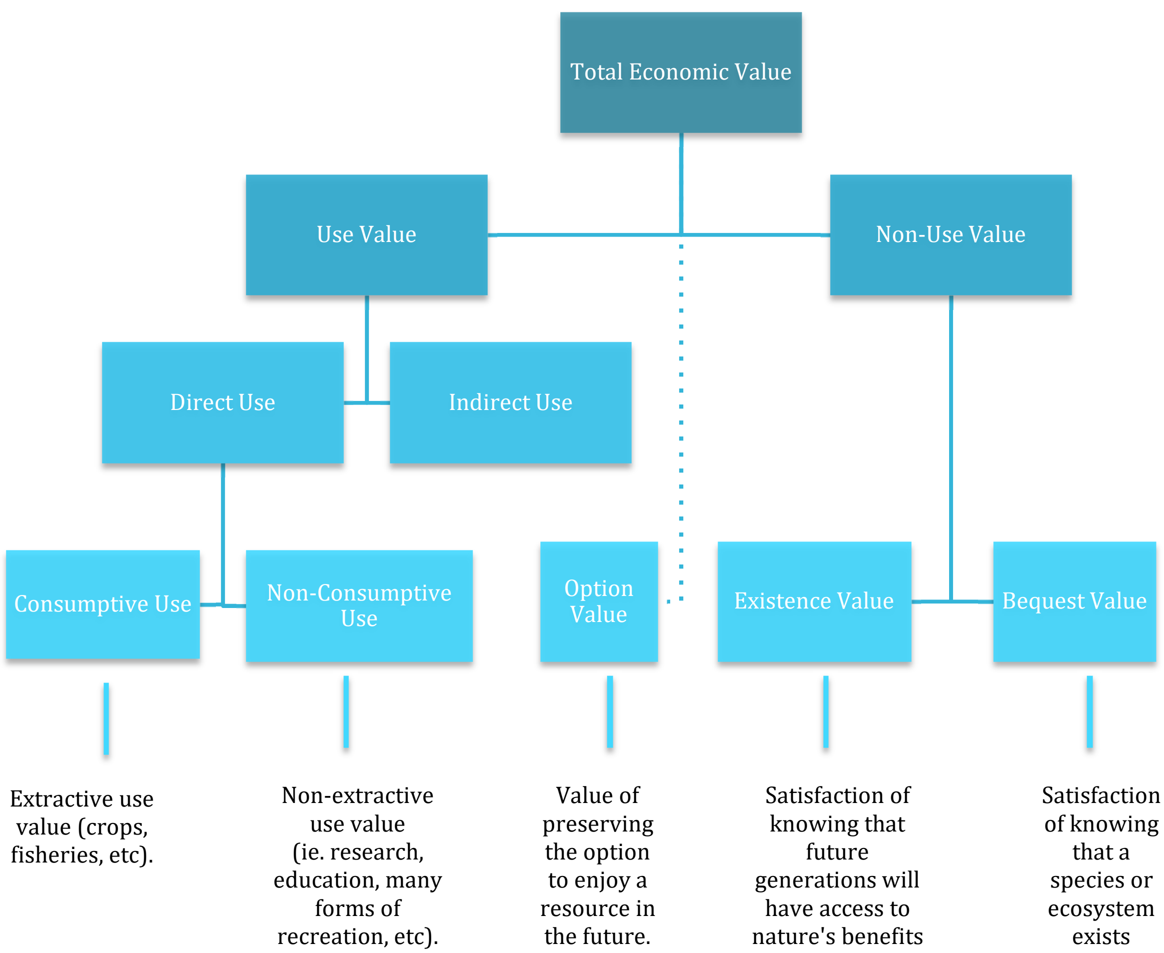

Figure 1 Depicts the relationship between economists' categories of value, and definitions for these values. ***The chart and definitions of value are largely borrowed from The Economics of Ecosystems and Biodiversity (TEEB 2010).***

B. Valuation of non-market goods

Many benefits provided by the environment, freshwater flows included, are public goods. Pure public goods are defined by economists as non-excludable and non-rival in consumption: individuals cannot be excluded from accessing these goods, and one person's use of the good does not diminish the benefit another derives from it. Clean air, for example, is a typical example of a public good. Because public goods are non-excludable, the market struggles to provide them at their optimum levels, and governments often end up providing them. Because these goods are therefore not bought or sold in markets and hence do not have prices, economists have devised strategies to value these non-market goods.

The first two methodologies in Table 1—revealed preference and cost-based valuations—use market data to value the non-market good (Hecht and Sunding 2013). Stated preferences relies on survey data derived from hypothetical markets. Benefit transfer relies on the extrapolation of known benefits from the original site of study to a new site (frequently referred to as the "policy" site).

Revealed Preference	Cost-Based	Stated Preference	Benefit Transfer
• Market price method • Productivity method • Hedonic pricing method • Travel cost method	• Damage cost method Replacement cost method • Substitute cost method	• Contingent valuation method • Choice experiments (conjoint analysis)	• Benefit value transfer • Benefit function transfer

Table 1: From Draft Bay Delta Conservation Plan Statewide Economic Impact Report (Hecht and Sunding 2013).

Amongst the non-market valuation methods most relevant to freshwater flow valuation are the travel cost method (TCM), contingent valuation method (CVM) and both benefit transfer methods.

1. Travel Cost Method: A valuation method where travel costs, which can be observed on the market, are used to estimate the value of a non-market activity, such as swimming in a river. For car travel, this would include wage opportunity cost, vehicle depreciation cost, and gasoline cost.
2. Contingent Valuation Method: Contingent valuation uses survey questionnaires to elicit how much people are willing to pay to maintain a resource at its current quantity or quality, increase the quantity or quality of a resource, or avoid a decrease in the quantity or quality of a resource. Some contingent valuation surveys elicit willingness to accept instead of willingness to pay.

3. Conjoint Analysis: Like CV, conjoint analysis is also a stated preference valuation method. Conjoint analysis elicits preferences for various attributes (i.e. for various levels of ecosystem services or for cost) from respondents.
4. Benefit Transfer Method: A valuation method where existing studies are used to infer benefits provided by other sites or resources.

III. Valuation Approaches and Studies for Water Resources

A. Travel Cost Method (TCM)

The travel cost method (TCM) is used by economists to value recreation benefits. Travel costs-- including gasoline, vehicle depreciation, and wage opportunity costs--are implicit costs to recreation; while recreational anglers may not pay fees for river access, the costs they incur in travelling to the river site amount to a lower bound for the value they place on a day of angling. TCM has been used on multiple occasions to value benefits of water-based recreation. In a study of whitewater boating and angling recreation demand in a New Mexico river, survey respondents were asked to estimate their travel costs and their likely usage of the site under several hypothetical stream flows. In this combination of travel cost estimation and stated preference, streamflow was found to significantly alter recreation demand and associated economic values (Ward 2009). TCM has been applied to value increased flow releases to wetlands—which increase quality—and associated recreation demand for waterfowl hunting (Creel and Loomis 1992). TCM was similarly applied to evaluate the link between resource quality and recreational demand in a study of the Peconic Estuary: water quality and catch rate were shown to significantly impact consumer surplus derived from swimming, boating, fishing, and shellfishing (Johnston et al. 2002).

A 2002 study by Loomis used TCM to weigh the costs of dam removal and subsequent recreation loss in reservoirs against increasing river recreational use, and found that while increased river recreation compensated for the loss of reservoir recreation, it did not fully compensate for the cost of dam removal (Loomis 2002). This finding, whereby recreational benefits of instream flows alone fail to justify optimum flows, has been found in multiple studies (Brown 1991).

While TCM has been extensively employed to value benefits of water- based recreation, its applications are limited: rather than capture the full swath of use and non-use values, TCM can only capture recreational use value. In the 1960s, economists began contemplating non-use environmental benefits: papers by Weisbrod (1964) and Krutilla (1967) introduced option value and bequest value, respectively (Hanemann 2005a). While Weisbrod's option value focuses on the value that people place on preserving their option to visit a site in the future, Krutilla's bequest value denotes the value people place on preserving a resource for enjoyment by future generations. Both of these values are captured by the contingent valuation method (CVM).

B. Stated Preference Methods: Contingent Valuation Method and Conjoint Analysis

Stated Preference Methods are the only valuation methods that measure Total Economic Value-- the sum of all use and non-use values. CVM is the more popular of the two stated preference methods. CVM measures Total Economic Value by asking survey respondents for their "Willingness to Pay" (WTP) or "Willingness to Accept" (WTA) to protect a resource (or alternatively, their WTP or WTA to either increase or avoid a decrease in the quantity or quality of that resource). This WTP or WTA is considered a sum of both use and non-use values.

Since the 1980s, environmental economic impacts have been evaluated for most water infrastructure projects (Hanemann 2005a). The ability of contingent valuation to measure Total Economic Value has made it a useful tool in many Benefit-Cost Analyses (BCA) for these proposed projects. CVM has been used to measure the cost of Glen Canyon dam to rafting in the Grand Canyon, and to evaluate the benefits of dam removal, which would triple salmon populations, on Washington's Elwha River (Bishop et al. 1989, Loomis 1996). In California, the EPA's 1993 Draft Regulatory Impact Assessment evaluated the impact of proposed increases in water quality, which they primarily hoped to achieve by increasing Delta outflow, on recreation and commercial fisheries. The impact to recreationists was in part measured with a stated preference survey, in which anglers were asked for their willingness to pay to increase their salmon and striped bass catch rate, or else avoid a decline in their catch rate. Results showed these anglers would be willing to pay \$5 per fish gained, and \$8 per fish to avoid a loss.

A contingent valuation survey was famously commission by the Water Board in 1993 to measure the public's willingness to pay for increased water levels in Mono Lake. The survey presented respondents with a variety of hypothetical water levels, and determined a positive public trust value for moderately increased lake levels (Jones & Stokes Associates 1994). The results aligned with the findings of an earlier CV study by Loomis, which showed that while the replacement cost of an alternative water supply would cost Los Angeles \$26.2 million annually, failure to alter the diversion rate from Mono Lake would represent a \$1.5-\$3.5 billion annual loss to the public trust (Loomis 1987). These results were used to advocate for reduced diversions from Mono Lake.

Most applicable to the Delta, in a study of wetland protection and avoided pollution from agricultural drainage, Loomis et al. found a \$1.8 billion public benefit to restoring Chinook salmon populations to the San Joaquin River (Loomis et al. 1991). A 2005 update of the study showed that WTP per household had declined slightly-- from \$183 per household to \$162 (Hanemann 2005b). This decline is attributed to the public's peak in interest in public trust resources during the original survey period (M. Hanemann, personal communication, July 29, 2016). Most recently, benefit cost analyses of California's WaterFix included a CV to measure non-use values generated by the project (The Brattle Group 2012). Although recreational use values are significant and should be included in valuations of benefits provided by water resources, non-use values (existence, bequest, and option values) are important components to the value of natural resources, and are expected to figure prominently where endangered and threatened species are concerned (Loomis et al. 2000). As one of only two methods designed to capture non-use values as well as use values, a contingent valuation study is the recommended valuation approach for the value of freshwater flows in the Delta. A conjoint analysis study is not recommended for reasons that will be explored later.

IV. Recommended Approach for Valuing Freshwater Flows in the San Francisco Estuary

A. Recommended Approach: CV

Due to the difficulty of isolating the economic impact of freshwater flows in existing markets, and the presumed importance of non-use value to the sum of freshwater flow value, a contingent valuation study is recommended for the economic valuation of freshwater flows in the San Francisco Estuary.

Although freshwater flows play important economic roles in the estuary --from avoided desalination costs for agricultural and urban users, to maintaining water quality that supports recreation--these values are difficult to identify in existing markets. Many other estuaries in the EPA's National Estuary Program have used market-based valuation methodologies (in addition to stated preference, in some cases) to value benefits provided by these systems. However, these studies all sum values generated by the system as a whole, and not freshwater flows specifically (Hindsley and Morgan 2014, Johnston et al. 2002, Kauffman and Cruz-Ortiz 2012). Furthermore, most studies measuring the economics of freshwater flows do so in rivers: in these systems, reduced freshwater flows often result in dry river beds, with evident losses to, for example, instream recreation (Loomis et al. 1991, Loomis 1996, Loomis 2002). By contrast, impacts of reduced freshwater flows in an estuary are not so clear: while reduced freshwater increases salinity, the economic impact of this salinity is difficult to discern without extensive data demonstrating the myriad of impacts from flow diversions. In addition, use of market data and a revealed preferences method confines the analysis to benefits provided by freshwater at its existing level, rather than analyzing benefits provided by increased flows (Carson and Czajkowski 2014).

Ojeda et al. addressed this difficulty by using CVM to value flows in Mexico's Yaqui River Delta (Ojeda et al. 2008). Interviewers described environmental services that would be sustained by the river delta were higher river flows restored, and respondents were subsequently asked for their WTP to increase freshwater flows. Environmental services described included habitat restoration, dilution of pollutants, maintenance of local fisheries, recreation, and non-use values. A similar approach is recommended for the SF Bay-Delta: by creating a hypothetical market and collecting survey data on people's preferences regarding flow diversion, a contingent valuation study presents a possibility for isolating the value of freshwater in this complex system. However, unlike in the study conducted by Ojeda et al., a valuation of the Delta should elicit WTA, not WTP. Water in the Delta belongs to the people of California, and therefor it is most appropriate to capture the minimum payment Californians are willing to accept to give up this water right (Niemi, E. and Wolff, G., personal communication, September 6, 2016).

Stated preference methods are the only valuation approaches that capture non-use value. Non-use value is believed to be a significant portion of the sum value people place on environmental goods (Carson and Czajkowski 2014). Therefore, measuring this value is critical to any valuation of freshwater flows in the San Francisco Estuary, and contingent valuation is the method most suited to achieve this.

B. Approach Not Taken: Conjoint Analysis

Conjoint analysis (CA) is not recommended for a valuation study of freshwater flows in the San Francisco Estuary. CA is particularly suited for valuation scenarios in which a variety of plans or goods are being considered (Farber and Griner 2002, Mansfield et al. 2012). CA elicits preferences for these plans by weighing different attributes, or plan outcomes, including ecosystem service impacts resulting from plan implementation, and the plan's cost. As a result of this complexity, the method collects more preference information per respondent. CA has gained popularity in recent years: a 2012 conjoint analysis of changes to the Klamath river basin weighed preferences for three different actions—dam removal, water-sharing agreements, and habitat restoration for fish—against cost (Mansfield et al. 2012). Since the study's completion, four dams have been slated for removal on the Klamath River, with the work scheduled to conclude by 2020 (Gilman 2016).

However, as a result of the increased flexibility, conjoint surveys are more difficult to design, and thus results may be less robust (M. Hanemann, personal communication, September 1, 2016). Furthermore, a Blue Ribbon Panel approved CV in 1992, but CA has yet to receive the same approval from the field of economics (Hanemann 2005b, Niemi, E., personal communication, September 6, 2016).

C. Approach Not Taken: TCM

Travel cost method (TCM) is ruled out as an appropriate valuation approach: TCM's narrow valuation abilities (confined to recreation use value) and the difficulty of applying TCM to the Delta's geography made the method unfit for our purposes. Non-recreation values have the potential to add substantially to the value of benefits provided by freshwater flows, and would be overlooked by TCM. Furthermore, TCM is more suitable when people are travelling substantial distances for recreation; by contrast, most Delta recreationists live within the Delta, traveling short distances to a variety of sites, rather than to a central hub (M. Hanemann, personal communication, July 29, 2016 and R. Norgaard, personal communication, July 27, 2016). Because TCM measures a lower bound for recreation value, these short travel distances may substantially underestimate the value of freshwater to recreationists.

D. Approach Not Taken: HPM

The hedonic pricing method is often applied in water resource valuation to measure the benefit of a waterfront location to property values. Because freshwater flows impact the salinity of the water, but not so much the presence of water in the estuary, a Hedonic Pricing approach is deemed inappropriate.

E. Approach Not Taken: BTM

Benefit transfer (BT) methods present a final possibility for the valuation of freshwater flows in the delta. The literature review found many studies valuing freshwater flows, but few in an estuarine ecosystem. Although the study by Ojeda et al. did measure services in such a system, this study was conducted in Mexico. Attempting to transfer results from survey data in Mexico, a developing nation with a population that differs widely from that in the United States, would violate principles of sound benefit transfer (DWR 2008). Although this literature review is not exhaustive, no studies were found where the ecological system, benefits provided by the system, and survey population were analogous to the Bay-Delta, and therefore presented a possibility for dependable benefit transfer. Nonetheless, due to the limitations of this literature review, it is possible that such studies exist.

It is possible to use BT to measure isolated benefits of freshwater flows. For example, Richardson and Loomis review 31 studies valuing endangered and threatened species to compose a meta-regression estimating the value people place on these species (Richardson and Loomis 2009). This meta-regression could be used to approximate the value placed on Fall and Spring run Chinook Salmon, Delta Smelt, longfin, and other threatened or endangered Delta species. If studies are found where sites and population characteristics are similar to the Delta, BT presents a valid possibility for the valuation of some freshwater flow benefits, particularly on a limited budget. However, values derived from transfers of separate studies should not be summed, since this would result in the double-counting of benefits.

Conclusion

The literature review of studies valuing instream flows advises that a contingent valuation method is the most appropriate method for freshwater flow valuation. Although contingent valuation (CV) has been criticized for its hypothetical nature, vulnerability to biases, and non-use value applications, it is a well-established methodology in environmental resource valuation (Birol and Koundouri 2006). Conducting a CV study will require extensive research into available data sources to properly model salinity, fishery, recreation, and other impacts from increased freshwater flows. Furthermore, these studies are expensive in both their questionnaire development and interview phases; should funding prove a limitation, more research should be done on evaluating benefits with benefit transfer, where possible.

Appendix: Glossary of Terms

Bequest value: The value people place on knowing that future generations will have access to benefits provided by a resource.

Benefit Cost Analysis: A method of analysis used to inform policy decisions, where costs of a project or proposal are weighed against benefits.

Benefit Transfer: A valuation method where existing studies (from the “study site”) are used to infer benefits provided by other sites (“policy site”) or resources.

Consumer surplus: The benefit consumers derive from a good over and above what they paid for the good. It is the difference between WTP and price.

Consumptive use: Use value that is extractive in nature (i.e. use of water for agriculture).

Contingent Valuation (CV): Contingent valuation uses survey questionnaires to elicit how much people are willing to pay to maintain a resource at its current quantity or quality, increase the quantity or quality of a resource, or avoid a decrease in the quantity or quality of a resource. Some contingent valuation surveys elicit willingness to accept instead of willingness to pay.

Direct use: Value derived from direct interaction with, or “use” of a resource. This use can be either consumptive or non-consumptive.

Existence Value: The value people place on knowing that a resource continues to exist.

Hedonic Pricing Method (HPM): A valuation method where the value of a non-market environmental good is estimated using a market good. HPM is most frequently used to value environmental amenities tied to property values—such as the value of having a view of the ocean from your home.

Indirect Use: Values that are derived from regulating ecosystem services. In contract to provisioning ecosystem services, which generate goods that are directly used by humans (i.e food), regulating ecosystem services are “not generally reflected in market transactions” (TEEB, p. 15). For example, these services include air quality regulation or flood control.

Market good: A product that provides people with utility, and is bought or sold in a market

Non-consumptive use: Use value that is not extractive in nature (i.e. use of water for instream purposes, including rafting, fishing, and swimming).

Non-excludable: A characteristic of a good whereby individuals cannot be excluded from accessing it (i.e. public beaches are non-excludable).

Non-market good: A product that provides people with utility, but is not bought or sold in a market. As such, non-market goods must be valued using non-market valuation methods. Many environmental services are considered non-market goods—i.e. salmon for recreational fishing.

Non-rival: A characteristic of a good whereby one person's use of the good does not diminish another's use (i.e. clean air is non-rival).

Non-use value: Value derived from ecosystems that is neither an indirect or direct use. Non-Use value includes bequest and existence values. Sometimes option value is also considered a non-use value. Non-use value is sometimes referred to as passive use.

Opportunity cost: The cost of lost opportunities when a course of action is taken. For example, when someone decides to go fishing there is an opportunity cost to this choice because they could have been working and earning money instead.

Option Value: The value people place on preserving the option to enjoy a resource in the future.

Public good: a good that is both non-rival and non-excludable in consumption. Many environmental goods, such as clean air, are public goods.

Total Economic Value (TEV): The sum of all use and non-use values from a good or service.

Travel Cost Method (TCM): A valuation method where travel costs, which can be observed on the market, are used to estimate the value of a non-market activity, such as swimming in a river. For car travel, this includes wage opportunity cost, vehicle depreciation cost, and gasoline cost.

Use value: Value derived from direct use of a resource. For example, use value includes value derived from agricultural use of diverted water, or alternatively, value derived from instream recreational uses (whitewater rafting, fishing, swimming, etc).

Replacement cost: The cost of replacing an item.

Revealed Preference Methods: Valuation methods that rely on the assumption that people reveal their preferences through their behavior. Therefore, these methods use peoples' choices for market goods to infer their preferences regarding non-market goods.

Stated preference methods: These valuation methods use surveys to determine value people place on a hypothetical change to the quantity or quality or a resource. Stated preference methods are at times also called choice experiments.

Willingness To Pay (WTP): The maximum amount an individual is willing to pay to access a good or service.

Willingness to Accept (WTA): The minimum amount an individual is willing to accept in order to give up a good or service.

Much of this glossary is based off definitions provided by The Economics of Ecosystems and Biodiversity (TEEB 2010).

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