GEF LME:LEARN

LARGE MARINE ECOSYSTEMS

ENVIRONMENTAL ECONOMICS FOR MARINE ECOSYSTEM MANAGEMENT TOOLKIT

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List of Acronyms

ABMJ	Areas Beyond National Jurisdiction
BCR	Benefit Cost Ratio
CARE	Comprehensive Assessment of Risk to Ecosystems
CBA	Cost Benefit Analysis
CBD	Convention on Biological Diversity
CEA	Cost Effectiveness Analysis
CICES	Common International Classification for Ecosystem Services
CITES	Convention on International Trade in Endangered Species
CTF	Conservation Trust Fund
CTI-CFF	Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security
CTMPAS	Coral Triangle Marine Protected Area System
DNS	Debt for Nature Swaps
EbA	Ecosystem based Adaptation
EBA	Ecosystem Based Approach
EBM	Ecosystem Based Management
EDF	Environmental Defence Fund
EEA	Experimental Ecosystem Accounting
EIA	Environmental Impact Assessment
ERA	Ecosystem Risk Assessment
ES	Ecosystem Services
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GEF	Global Environmental Facility
IAM	Integrated Assessment Model
ICES	International Council for the Exploration of the Seas
ICM	Integrated Coastal Management
IEEFM	Integrated Ecological-Economic Fisheries Models
IMF	International Monetary Fund
INCA	Integrated system for Natural Capital and ecosystem services Accounting
IOC	International Oceanographic Commission
IRR	Internal Rate of Return
ITQ	Individual Transferable Quota
IUU	Illegal, Unreported, and Unregulated Fishing
LME	Large Marine Ecosystem
LME:LEARN	Large Marine Ecosystems: Learning Exchange and Resource Network
MCA	Multi Criteria Analysis
MPA	Marine Protected Area
MSP	Marine Spatial Planning
NGO	Non-Governmental Organisation
NPV	Net Present Value
NPV	Net Present Value
OECD	Organisation for Economic Cooperation and Development
PEMSEA	Partnerships in Environmental Management for the Seas of East Asia
PES	Payments for Ecosystem Services
SCC	Social Cost of Carbon
SECA	Simplified Ecosystem Capital Accounts
SEEA	System of Environmental-Economic Accounting
SIA	Sustainability Impact Assessment
SNA	System of National Accounts
TAC	Total Allowable Catch
TDA	Transboundary Diagnostic Analysis
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
TURF	Territorial Use Rights for Fishing
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
VA-LEAP	Vulnerability Assessment Local Early Action Plan
WAVES	Wealth Accounting and Valuation of Ecosystem Services
WRI	World Resources Institute
WTO	World Trade Organisation

1. Introduction

The Environmental Economics for Marine Ecosystem Management Toolkit (in further text: Toolkit) has been developed within the GEF Large Marine Ecosystems Learning Exchange and Resource Network (GEF LME:LEARN) project. GEF LME:LEARN is a GEF-UNDP-IOC/UNESCO project designed to improve global ecosystem-based governance of Large Marine Ecosystems (LMEs) and their coasts by generating knowledge, building capacity, harnessing public and private partners and supporting south-to-south learning and north-to-south learning. A key element of this improved governance is mainstreaming cooperation between LME, Marine Protected Area (MPA), and Integrated Coastal Management (ICM) projects in overlapping areas, both for GEF projects and for non-GEF projects. This full-scale project plans to achieve a multiplier effect using demonstrations of learning tools and toolboxes, to aid practitioners and other key stakeholders, in conducting and learning from GEF projects.

In pursuit of its global and regional objectives, GEF LME:LEARN seeks to strengthen global governance of large marine ecosystems and their coasts through enhanced sharing and application of LME/ICM/MPA knowledge and information tools.

1.1 Purpose of this toolkit

The purpose of this toolkit is to show how environmental economic methods can be used to produce information to support decision-making in the context of LME, MPA, ICM, Marine Spatial Planning (MSP) and climate change adaptation. Specifically, it is designed to help a broad audience of practitioners, managers, government officials, private sector managers, NGOs, and statisticians to understand the available environmental economic tools and how the information generated can be used to inform the decisions that they make.

The broad objective of this toolkit is to provide an understanding of how environmental economic methods can be used to support decision-making in the context of LME/MPA/ICM. To this end, the Toolkit provides:

1. A brief introduction to key environmental economic principles that are relevant to LME/MPA/ICM,
2. Non-technical explanations of environmental economic methods and their applicability to different decision contexts,

3	An explanation of the strengths and weaknesses of environmental economic methods and potential uncertainties,
4	Links to available resources for each environmental economic method,
5	Illustrative applications of the use of economic methods for different scales and decision-making contexts for LME/MPA/ICM.

1.2 Why use environmental economic methods

Environmental economic methods broadly involve identifying and quantifying the economic value of environmental resources and impacts, and incorporating this information into decision-making and the design of financing mechanisms and policy instruments.

Economic value is simply a means to describe how important the things we use are to us, including our use of the natural world or "natural capital". Estimating an economic value for environmental resources begins with an understanding of the many different goods and services that the environment can provide (for short, these are termed "ecosystem services") and the contribution these goods and services make to the wellbeing of the people that benefit from them (see Figure 1). The concept of ecosystem services provides a framework for identifying and quantifying the variety of benefits that we obtain from the environment (see Definition Box 1)

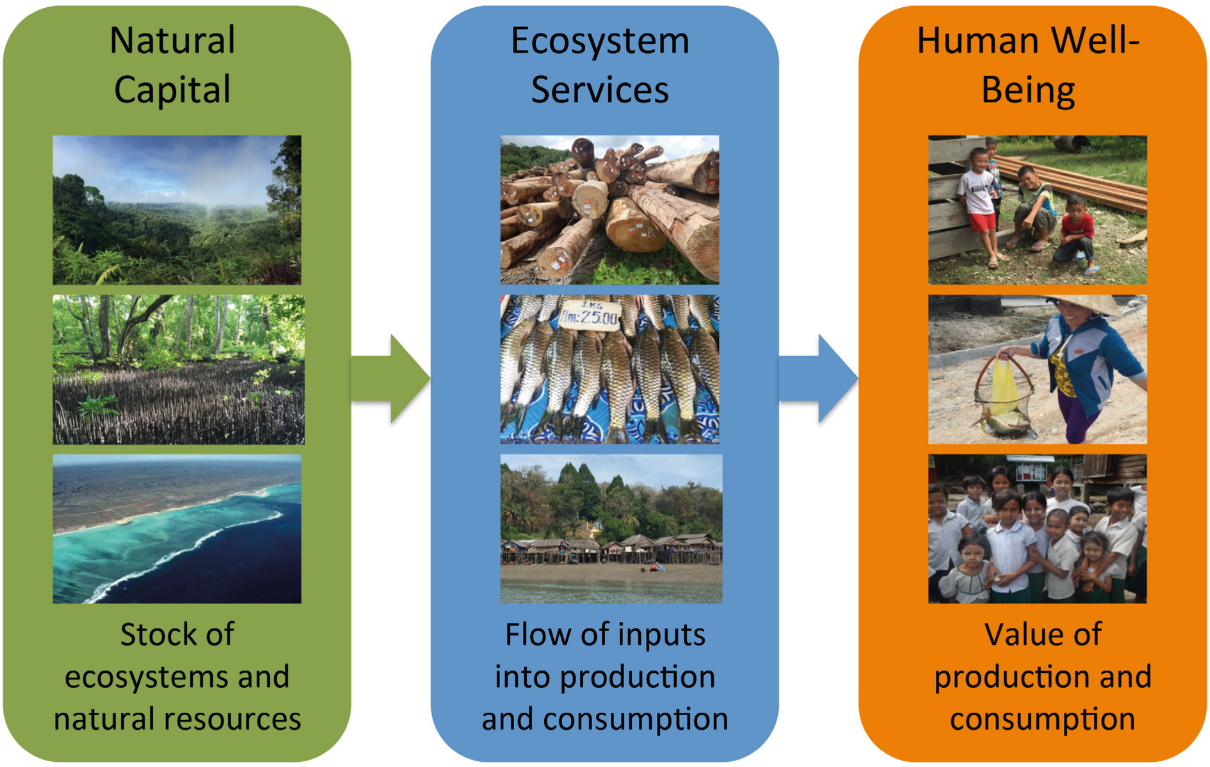

Figure 1: The contribution of natural capital and ecosystem services to human well-being

In the case of ecosystem services from the marine environment, there are often no prices that reflect their value, since the services that are provided are not traded in markets (e.g. climate regulation, coastal protection, biodiversity). As a result we tend not to take the value of ecosystem services into consideration when we make decisions that affect the marine and coastal environment. When we investigate the consequences of environmental change (e.g. climate change, development, marine accidents) we need to fully understand the effects on ecosystem services and human wellbeing. Economic valuation tries to measure the importance of environmental change, usually in monetary terms, in order to communicate the scale of impacts to human wellbeing. Such information can be used to raise awareness of the economic importance of marine ecosystems, set fees for the use of marine ecosystem services, or determine compensation payments for environmental damage.

In the context of development planning or investment in environmental management, economic appraisal methods can be used to explicitly examine trade-offs between the costs and benefits of alternative options. Often, decisions regarding economic development affect the functioning or quality of ecosystems. Although such decisions are intended to enhance development, they can also reduce the supply of ecosystem services that are critical to human well-being and sustainable development. If, for example, we choose to clear a mangrove for aquaculture development, then a trade-off is made between the ecosystem services provided by the mangrove that we will forgo and the benefits that will accrue under the new development. Economic appraisal methods make that trade-off explicit and allow the alternatives to be directly compared to reveal clearly to decision makers what will be lost or gained by making a decision.

Example Box 1: Using economic values to make explicit trade-offs between resource uses

This example uses data from Southern Thailand to illustrate how information on economic values can be used to make explicit trade-offs between alternative land uses (see Figure 2). In this case, the choice is between maintaining mangroves or conversion to aquaculture shrimp ponds. From the perspective of the private landowner (Panel A), conversion to shrimp ponds makes good sense since the profits from shrimp ponds greatly exceed the profits that can be made from harvestable mangrove forest products. This difference in profitability is much less, however, if the subsidies to shrimp farming are removed (Panel B). From a societal perspective (Panel C), the conversion to shrimp ponds is not a good investment for two reasons: 1. There are high public costs of restoring degraded land after it has been used for shrimp farming; 2. There are high public benefits from maintaining mangroves that support local fisheries and provide protection to coastal communities from storm damage.

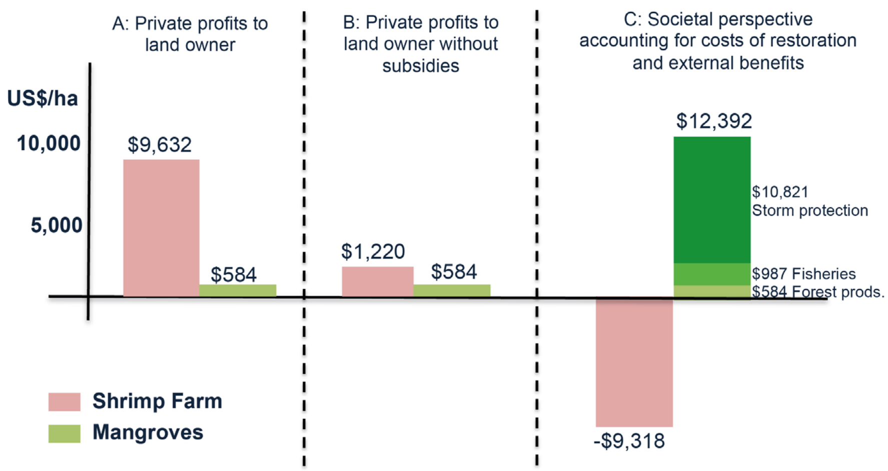

Figure 2. Net benefits of shrimp farms and mangroves in Southern Thailand. Values are 1996 US$ net present values over 9 years (1996-2004) using a 10% discount rate. Data from Barbier (2007).

Under pressure to respond to immediate problems, but hampered by a lack of high quality information and analysis, decision makers often have to make quick decisions without full knowledge of the long term implications of their decisions. Having access to reliable information that describes the costs, values, and risks of environmental change facilitates more objective, more transparent and better informed decision-making. Such information should reduce the pressure on decision makers by giving them a fuller and more balanced understanding of the economic gains from environmentally sustainable policies, projects and decisions, and the potential losses from unsustainable ones.

Environmental economic methods do not provide the 'correct' answer to questions on marine environmental conservation and management, but are intended to provide information to facilitate more objective decision-making. They provide a means of measuring the implications of decisions on environmental management, not just to the immediate stakeholders, but also to people impacted by environmental change further afield and to future generations.

Environmental economic methods do not stand alone but are often used in combination with other (usually biophysical) methods for assessing environmental change and the provision of ecosystem services. The added value of using economic methods is that the consequences of environmental change are expressed in terms of human welfare and measured in common units (i.e. money) that can be directly compared to other costs and benefits that decision-makers need to consider.[1]

There are many contexts in which environmental economic methods may be useful, including to:

- Raise ***awareness*** of the value of the marine environment. Estimates of the economic value of an LME or MPA can highlight its importance to the public and to policy makers (see example of the Sargasso Sea ecosystem in Box 1);
- Design effective ***policy instruments*** for environmental management. Resource use and polluting activities within an LME can be managed using economic instruments such as taxes, transferable quotas, certification and labelling, and trade restrictions;
- Design mechanisms for ***sustainable financing***, including setting appropriate *fees* for use of ecosystem services. This is relevant to LMEs and MPAs to sustain financing after initial project funding ends;
- **Compare *costs and benefits*** of alternative uses of the environment. This may be done, for example, in the context of Marine Spatial Planning to evaluate the net benefits from alternative activities;
- Reveal the ***distribution of costs and benefits*** of management decisions among different stakeholders. Transparently measuring who incurs the costs and who receives the benefits of LME management provides key information for decision makers;
- Calculate values for ecosystem services and natural capital for input into ***green accounts***. Information on the value of ecosystem services can also be used in Transboundary Diagnostic Assessments (TDAs) of LMEs to indicate their socio-economic importance;
- Calculate the value of environmental ***damages to set compensation***. Information on the full economic costs of marine accidents (e.g. oil spills, ship groundings) can be used to determine the level of compensation that needs to be paid.

1 It should be noted that this toolkit employs an economic definition of value in which human preferences for all ecosystem services can be measured in monetary units. This allows the aggregation of values across ecosystem services and the comparison of values for ecosystem services with the values of other goods and services in the economy. It should be noted, however, that some ecosystem services may be very difficult to quantify in monetary terms (e.g. biodiversity, non-use values) and that other conceptualizations of 'value' (e.g. non-anthropocentric concepts of intrinsic values for nature) fall outside of this theoretical framework. Other concepts of value may, in some contexts, be useful for promoting sustainable marine management.

Specifically, in the context of LME management, economic methods can be used to measure socio-economic indicators and evaluate management options within the Socio-Economics Module of the 5-module Strategic Approach to LME management. The ❯❯ Strategic Approach toolkit Section 2.4 provides detail on the parameters and indicators that are used within this module.

Example Box: Ecosystem services provided by the Sargasso Sea

The Sargasso Sea lies in an area beyond national jurisdiction, except for the territory of Bermuda and the Bermudian Exclusive Economic Zone. Ocean currents, global biochemical cycles, and wide-ranging ecological processes result in the Sargasso Sea delivering ecosystem services well beyond its own boundaries.

The ecosystem services provided by the Sargasso Sea vary widely in terms of type and beneficiary. Some of its services may be harvested directly (e.g., fish). Other ecosystem elements, such as Sargassum – a floating sea plant – supports part of the life cycle of organisms that ultimately benefit people far from the region. For example, eels that spawn in the Sargasso Sea are later harvested in North America and Europe. The Sargasso Sea also provides important habitat for whales and turtles that return to near shore, continental waters where they support local tourism industries. The Sargasso Sea also generates non-use and regulating services that benefit people globally.

A recent study provides the best available information about the potential economic magnitude or nature of the Sargasso Sea's ecosystem services (Pendleton *et al.* 2014). The study concludes that economic impacts and benefits directly or potentially linked to the Sargasso Sea may total between tens to hundreds of million dollars a year. The findings show the ecological health of the Sargasso Sea is not only in the interest of the inhabitants of Bermuda. Better management, including marine protection of the Sargasso Sea would benefit people and businesses around the globe, in particular, in North America (whale watching), Europe (eel fisheries), and elsewhere in the Americas (commercial fishing).

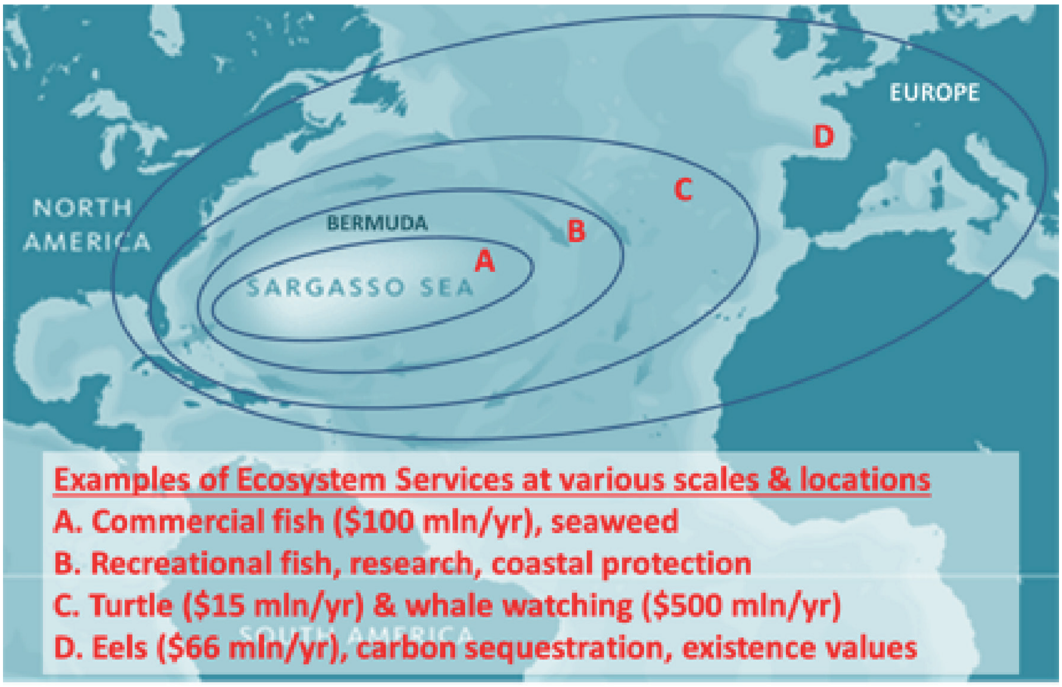

Figure 3. Ecosystem services benefiting people in various locations

Definition Box 1: Ecosystem Services

A number of different definitions of ecosystem services have been developed through different initiatives. These include:

Ecosystem services are the benefits that ecosystems provide for people (Millennium Ecosystem Assessment – MA, 2005).

Ecosystem services are the direct and indirect contributions of ecosystems to human well-being (TEEB, 2010)

Ecosystem services refer to those contributions of the natural world that are used to produce goods which people value (UK National Ecosystem Assessment – UKNEA, 2011).

Ecosystem services are the contributions that ecosystems make to human well-being (CICES, 2012).

Similarly there are a number of different classification systems for ecosystem services including those developed by the Millennium Ecosystem Assessment, The Economics of Ecosystems and Biodiversity, and the Common International Classification of Ecosystem Services. All classifications make a distinction between "provisioning", "regulating" and "cultural" services. The Millennium Ecosystem Assessment classification also includes the category "supporting" services.

Provisioning services are the "products obtained from ecosystems". Examples include food, timber and fuel.

Regulating services are the "benefits obtained from the regulation of ecosystem processes". Examples include water flow regulation, carbon sequestration and protection from storms.

Cultural services are the "non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences".

Supporting services "are necessary for the production of all other ecosystem services". Examples include nutrient cycling, soil formation and primary production.

The distinction between supporting services and other ecosystem services is the difference between "intermediate" and "final" ecosystem services. Final ecosystem services are the last item in the chain of natural processes that provide inputs to the generation of products (goods and services) that are used by humans. Some final ecosystem services are used as inputs in the production of manufactured products (e.g. mangrove trees used to make charcoal) whereas others are consumed directly (e.g. a beach used for recreation). Intermediate ecosystem services are natural processes that contribute to final ecosystem services, but do not directly input into the production of goods and services consumed by humans (UKNEA, 2011)

The International Platform on Biodiversity and Ecosystem Services (IPBES) also use the term "nature's contribution to people" which refers to "all the benefits that humanity obtains from nature. Ecosystem goods and services considered separately or in bundles, are included in this category. Within other knowledge systems, nature's gifts and similar concepts refer to the benefits of nature from which people derive a good quality of life. Aspects of nature that can be negative to people, such as pests, pathogens or predators, are also included in this broad category" (Diaz et al., 2015). This concept attempts to integrate various knowledge systems and emphasises that the value of nature's contributions to people can be positive or negative.

1.3 Who should use this toolkit

The toolkit has been designed to help anyone involved in management of LME/MPA/ICM to understand and use environmental economic methods to support their work. Potential users include:

- Senior / middle level managers. Environmental economic analysis is potentially a useful source of information for appraisal of alternative management measures or for demonstrating the benefits of improved management,
- Policy makers in sector ministries (e.g. environment, fisheries, transportation, energy). Information from environmental economic analysis may be used in policy appraisal, damage assessment, budget decisions and the design of policy instruments to finance and manage LMEs,
- Private sector. There is an increasing interest in understanding the importance of environmental resources from the perspective of private enterprises, either as inputs into production or as outputs (external costs and benefits) to society. Environmental economic methods are potentially useful as a source of information for full cost accounting, Triple Bottom Line analysis, and calculating environmental profit and loss,
- NGOs. Information on the economic value of the marine environment can be used to communicate the importance of good management to society. The use of economic language can be more effective in communicating this message to some stakeholders and decision makers, and
- Statisticians and accountants. Several international initiatives are underway to incorporate environmental resources into national accounts and reporting systems (e.g. the Convention on Biological Diversity Aichi Target 2). Environmental economic methods provide a consistent and structured approach to deliver this type of information.

1.4 How to use this toolkit

The aim is to provide a practical handbook to guide the use of environmental economic methods in the context of LME/MPA/ICM. To be able to use the toolkit, a basic understanding and experience of applied environmental economics is useful but not necessary. For users that are unfamiliar with environmental economics or need a refresher, a brief introduction to relevant basic principles is provided in Chapter 2.

Each section of the Toolkit describes a distinct method that is potentially relevant to LME/MPA/ICM management. Users can go directly to the sections that are relevant to their needs. Links between methods are highlighted so that users can navigate between sections to suit their purposes. The Toolkit provides an introduction to each method, guidance on what information it can be used to produce, and its strengths and limitations. It does not provide step-by-step technical instructions on how to conduct each method since many of the methods require separate dedicated manuals to themselves. Throughout the Toolkit, references are made to other useful resources and guidance, including the other GEF LME:LEARN Toolkits. This Toolkit can and should be used alongside these other resources.

1.5 Quick overview of the tools and when to use them

To give an overview of the contents of this toolkit, here we provide a brief overview of the environmental economics methods that are covered and indicate when to use them.

Because environmental economic analysis is undertaken for a variety of purposes in a variety of contexts, it is not possible to present a uniform framework for the use of environmental economic methods. In other words, each new assessment may require a slightly different approach from other applications. The selection of appropriate tools will largely depend on the policy application to which the analysis contributes. This toolkit provides guidance on what each method can be used for and its strengths and limitations.

Figure 4 represents the common links between policy applications and environmental economic methods; and links between methods in the case that output from one method is used as input into another. For example, it shows that economic appraisal frameworks (e.g. cost-benefit analysis) are predominantly used for evaluating policy and investment options; that economic valuation of marine ecosystem services can be used for awareness raising, designing sustainable financing mechanisms, designing other policy instruments, and for setting compensation for damage to marine ecosystems; and that economic valuation is also used as an input into natural capital accounting and economic appraisal.

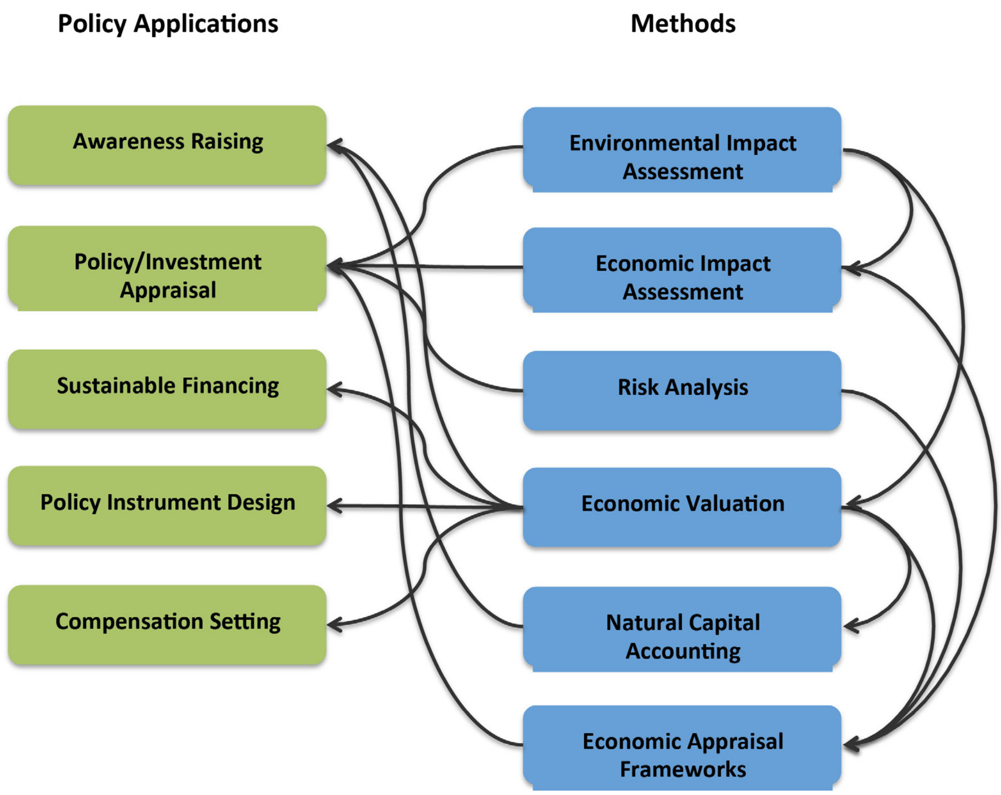

Figure 4: Policy applications and environmental economic methods

The ordering of methods, from top to bottom in the Figure 4 (and in the chapters of this toolkit), broadly follows the steps in an assessment along the "impact pathway" from environmental change, identification of impacts, risk analysis, valuation, design of policy instruments, appraisal and decision support.

It should also be noted that economic assessment is just one element in a decision process, along with a number of other steps that require expertise beyond the economic domain. A general description of a decision process that involves impacts on the environment includes the following steps: problem identification, identification of impacts, bio-physical assessment, valuation, determination of policy or investment options, policy evaluation and decision support. These steps might require inputs from many other fields of expertise (e.g. climate scientists, marine biologists, coastal geographers, hydrologists, ecologists, policy analysts, and experts in decision support). Although the emphasis of this toolkit is on environmental economic methods, these other crucial elements in the assessment process should not be ignored and many are supported by other GEF LME:LEARN toolkits, which are referenced where appropriate.

2. Environmental Economics : Basic principles

This section provides a brief non-technical introduction to key environmental economic concepts and principles that are relevant to LME/MPA/ICM assessment and management, including public goods, common pool resources, externalities, economic value and economic policy instruments.

2.1 Public goods and common pool resources

Goods, services and resources can be usefully defined by two characteristics: (1) excludability – the feasibility of excluding others from access and use; and (2) rivalry – the extent to which use by one person reduces the quantity available to others. To some extent, these characteristics are inherent in the nature of the good, service or resource (from hereon "goods" for short) but can also be determined by social and legal institutions.

Goods with different combinations of excludability and rivalry characteristics can be classified accordingly. Table 1 summarises the possible combinations of these characteristics to define different types of goods. Those that are excludable and rival are termed "pure private goods". It is possible to exclude others from using such goods and consumption by one person directly reduces the quantity available to others. Examples of pure private goods are offshore fossil fuel reserves and aquaculture cages. Goods that are excludable but non-rival are termed "club goods". An example of a club good is genetic information extracted from coral for pharmaceutical applications. Other potential users of this information can be excluded through the patent system but use of the information does not reduce the quantity available to others. Goods that are non-excludable and rival are termed "common goods" or in the case of resources, "common pool resources". In the absence of access controls, fish stocks are examples of common pool resources in the sense that it is not feasible to exclude fishers from harvesting from the stock but their catch reduces the quantity available to other fishers. The implications for resource use and management of common pool resources is returned to later. Goods that are both non-excludable and non-rival are termed "pure public goods". Examples include public beaches (up to the point that crowding results in rival use) and climate regulation provided by the storage of carbon in marine ecosystems. In the case of climate regulation, it is not feasible to exclude anyone from benefiting from this service and one person's benefit from an equable climate does not reduce the benefit to anyone else.

Table 1: Combinations of excludability and rivalry characteristics used to classify different types of goods, services and resources

	EXCLUDABLE	NON-EXCLUDABLE
RIVAL	Pure Private Goods (e.g. offshore oil and gas; aggregates; aquaculture cages)	Common Goods (e.g. fish; pollution sinks)
NON-RIVAL	Club Goods (e.g. private beaches, genetic material)	Pure Public Goods (e.g. public beaches; climate regulation)

The characteristics of excludability and rivalry have important implications for how a good, service or resource is produced, used and managed. Open access common pool resources, including many fisheries and particularly those that have transboundary stocks or are in Areas Beyond National Jurisdiction (ABNJ), have a tendency towards overexploitation because individual users do not have an incentive to invest in maintaining the resource. This overuse of common pool resources has been eloquently described as "the tragedy of the commons" (Hardin, 1968). Chapter 8 introduces a number of policy instruments that can be used to regulate the use of common pool resources.

Pure public goods tend to be under-provided by markets (quantities are lower than socially optimal levels), unprotected by property rights, or not provided at all. The reason why private enterprises do not supply public goods is that they cannot restrict use to only those consumers who have paid for the good. In addition there is a free rider problem in that there is no incentive for consumers to pay for a good that they can obtain for free if someone else pays. In the absence of markets providing public goods there are strong arguments for governments to supply them. This requires, however, that governments know how much of a public good people want. Non-market economic valuation studies can be used to provide such information (see Chapter 6).

2.2 Externalities

The term "externality" is used to describe a negative or positive impact on the welfare of one economic agent resulting from the behaviour of another economic agent, without that impact being agreed to by the impacted party. For example, nutrient runoff from agricultural land may end up in the sea causing eutrophication and consequently damage to coastal fisheries. This is a negative externality from agricultural activities that is incurred by the fishery. An example of a positive externality is the increase in marine biodiversity resulting from the nursery function provided by offshore wind power turbines, which might be enjoyed by coastal tourists. This is a positive externality from the power producer to the tourists.

A negative externality is also called an "external cost"; and a positive externality is called an "external benefit". In other words, these are costs and benefits that are external to the economic agent that generated them. The implication of external costs is that since the economic agents that generate the cost do not incur it themselves, they ignore it in their decision making and produce more than they otherwise would. The reverse is true for external benefits; economic agents that generate external benefits would produce more if the benefit accrued to themselves.

Externalities can be caused by both production and consumption activities; and also incurred by both producers and consumers. The above example of nutrient runoff is a production-to-production externality; and the example of wind turbines supporting marine biodiversity is a production-to-consumption externality.

Many environmental problems can be characterised as externalities. The over-exploitation of common pool resources such as fisheries is driven by an externality. An external cost is generated when one fisherman catches fish, thereby reducing the availability of fish for others to catch and increasing their costs of catching fish. Moreover, this external cost reduces the incentive for any fisherman to invest in maintaining the fish stock for future use since others can harvest any investment.

Other examples of external costs in the context of LME/MPA/ICM are other forms of marine pollution (marine plastics, oil spills, ship waste, deep sea mining), underwater noise, ocean acidification, ocean warming, and sea level rise. Chapter 6 outlines the available economic methods for valuing externalities to understand their implications for human welfare and to design policy instruments to manage them. Chapter 8 introduces a number of policy instruments that can be used to regulate externalities or internalise them so that the economic agents that generate them take them into account.

2.3 Economic value

Economic value is a measure of the human welfare derived from the use or consumption of goods and services. Economic valuation is one way to quantify and communicate the importance of something (e.g. environmental damage, changes in resource availability, ecosystem services etc.) to decision makers, and can be used in combination with other forms of information (e.g. bio-physical indicators and social impacts). The comparative advantage of economic valuation is that it conveys the importance of environmental change directly in terms of human welfare and uses a common unit of account (i.e. money) so that values can be directly compared across other goods, services, investments and impacts in the economy.

Here we provide definitions of the various concepts of economic value that are relevant to the assessment and management of LMEs.

In neo-classical welfare economics, the economic value of a good or service is the monetary measure of the wellbeing associated with its production and consumption. In a perfectly functioning market, the economic value of a good or service is determined by the demand for and supply of that good or service. Demand for a good or service is determined by the benefit, utility or welfare that consumers derive from it. Supply of a good or service is determined by the cost to producers of producing it. Figure 5 Panel 1 provides a simplified representation of demand (marginal benefit) and supply (marginal cost) for a good traded in a market at quantity 'Q' and price 'P'.

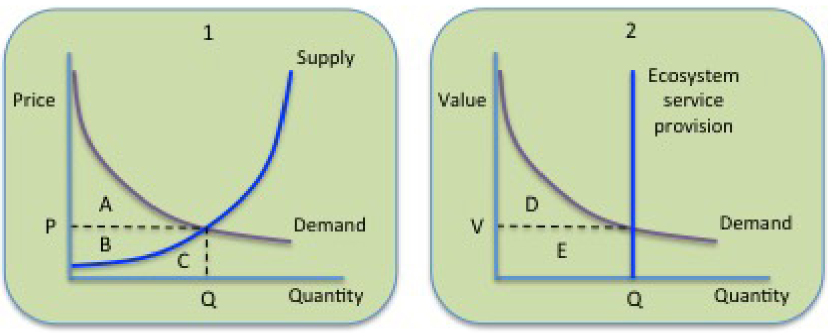

Figure 5: Demand and supply

In Figure 5 Panel 1, area 'A' represents the **consumer surplus**, which is the gain obtained by consumers because they are able to purchase a product at a market price that is less than the highest price they would be willing to pay (which is related to their benefit from consumption and represented by the demand curve). The **producer surplus**, depicted by 'B', is the amount that producers benefit by selling at a market price that is higher than the lowest price that they would be willing to sell for (which is related to their production costs and represented by the supply curve). The area 'C' represents production costs, which differ among producers and/or over the scale of production. The sum of areas A and B is labelled the 'surplus', and is interpreted as the net economic gain or welfare resulting from production and consumption with a quantity of Q at price P.

In the case that goods and services are not traded in a market (as is the case for many ecosystem services such as climate regulation, coastal protection and biodiversity), the interpretation of the welfare derived from their provision can also be represented in terms of surplus. Figure 5 Panel 2 represents the supply and demand of a non-marketed service. In this case, the service does not have a supply curve in the conventional sense that it represents the quantity of the service that producers are willing to supply at each price. The quantity of the service that is 'supplied' is not determined through a market at all but by other decisions regarding protection status, land use, management, access etc. The quantity of the service supplied is therefore independent of its value. This is represented in Figure 5 Panel 2 as a vertical line. The demand curve for non-marketed services is still represented as a downward sloping line since marginal benefits are expected to decline with quantity (the more that we have of a service, the lower the additional welfare of consuming more). In this case, consumers don't pay a price for the quantity (Q) that is available to them and the entire area under the demand curve (D+E) represents their consumer surplus. It is useful to keep this Figure in mind when considering the measurement of service supply from an LME and the welfare people derive from it.

Note that the demand for goods and services that are used as inputs into the production of marketed goods and services (e.g., the habitat and nursery service provided to fisheries by mangroves and coastal wetlands are generally uncompensated inputs into fisheries production) is derived from the demand for the good or service that is finally consumed (e.g. fish).

The **marginal value** of a good or service is the contribution to wellbeing of one additional unit. It is equivalent to the price of the service in a perfectly functioning market (P in Figure 5). Small changes in ecosystem service provision should be valued using marginal values. The **average value** of a good or service can be calculated as its total value divided by the total quantity of the service provided and consumed. From Figure 5 Panel 2, average value can be calculated as (D+E)/Q. Average values may be useful for comparing the aggregate value of a good or service relative to the scale of provision (defined in terms of units of provision, area of ecosystem or number of beneficiaries).

Total Economic Value (TEV)

The concept of Total Economic Value (TEV) of an ecosystem is used to describe the comprehensive set of utilitarian values derived from that ecosystem. This concept is useful for identifying the different types of value that may be derived from an ecosystem. TEV comprises of **use values** and **non-use values**. Use values are the benefits that are derived from some physical use of the resource. **Direct use values** may derive from on-site extraction of resources (e.g. fisheries) or non-consumptive activities (e.g. recreation). **Indirect use values** are derived from off-site services that are related to the resource (e.g. climate regulation, coastal protection). **Option value** is the value that people place on maintaining the option to use an ecosystem resource in the future. Non-use values are derived from the knowledge that an ecosystem is maintained without regard to any current or future personal use. **Non-use values** may be related to altruism (maintaining an ecosystem for others), bequest (for future generations) and existence (preservation unrelated to any use) motivations. The constituent values of TEV are represented in Figure 6. It is important to understand that the "total" in Total Economic Value refers to the identification of all components of value rather than the sum of all value derived from a resource. TEV is a comprehensive measure, as opposed to a partial measure, of value. Accordingly, many estimates of TEV are for marginal changes in the provision of ecosystem services but "total" in the sense that they take a comprehensive view of sources of value.

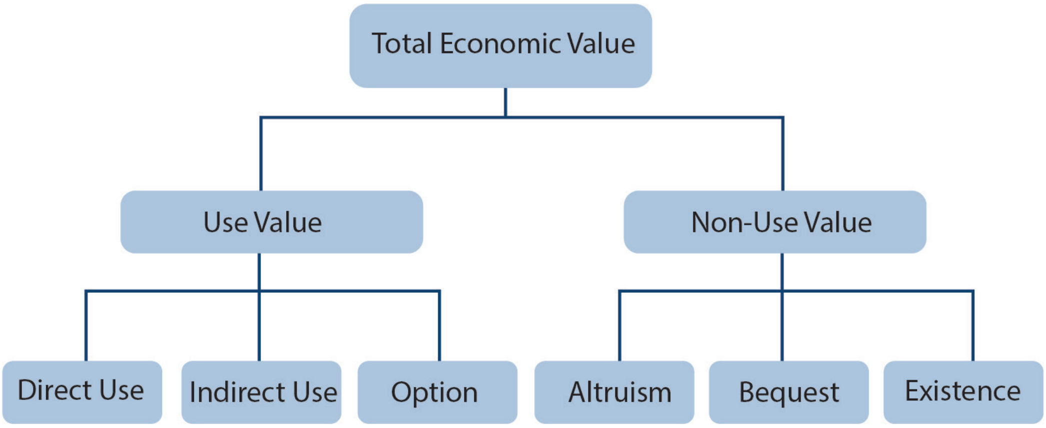

Figure 6: The components of Total Economic Value

The classification of different types of economic value within the concept of TEV is complementary to the classification of ecosystem services. Table 2 sets out the correspondence between categories of ecosystem service and components of TEV.

Table 2: Correspondence between ecosystem services and components of Total Economic Value

ECOSYSTEM SERVICE	TOTAL ECONOMIC VALUE			
	DIRECT USE	INDIRECT USE	OPTION VALUE	NON-USE
Provisioning	E.g. fish		Option to use Provisioning service	
Regulation and maintenance		E.g. climate regulation	Option to use Regulating service	
Cultural	E.g. recreation		Option to use Cultural service	E.g. bequest value

Exchange value

The concept of welfare value is used in most assessments of ecosystem services but it is not used in the System of National Accounts (SNA) that is used to calculate Gross Domestic Product (GDP) and other economic statistics. The SNA uses the concept exchange value, which is a measure of producer surplus plus the costs of production. In Figure 5 Panel 1 this is represented by areas B and C, or equivalently P times Q. Under the concept of exchange value, the total outlays by consumers and the total revenue of the producers are equal. For national accounting purposes, this approach to valuation enables a consistent and convenient recording of transactions between economic units since the values for supply and use of products are the same. In the context of comparing the values of ecosystem services with values in the system of national accounts, it is therefore necessary to value the total quantity of ecosystem services at the market prices that would have occurred if the services had been freely traded and exchanged. In other words, it is necessary to measure exchange value and not welfare value.

The differences between the concepts of welfare value and exchange value are the inclusion of consumer surplus (A) in the former and the inclusion of production costs in the latter (C). The concept of welfare value corresponds to a theoretically valid measure of welfare in the sense that a change in value represents a change in welfare for the producers and/or consumers of the goods and services under consideration. The concept of exchange value does not correspond to a theoretically valid measure of welfare and a change in exchange value does not necessarily represent a change in welfare for either producers or consumers (Day, 2013).[2]

2.4 Economic policy instruments

The term "policy instrument" is used to mean the mechanisms through which governments achieve a desired objective. Table 3 provides an overview of the main categories of environmental policy instrument. In general, economic policy instruments attempt to change the behaviour of stakeholders (e.g. consumers, fishers, resource users) by changing incentives that influence their decisions. Examples of economic policy instruments include taxes and subsidies, tradable permits or quotas, regulation of trade, and payments for ecosystem services. Chapter 8 provides detail on a number of policy instruments relevant to LME/MPA/ICM. The term "policy tool" on the other hand refers to frameworks, methodologies and models that can be used to inform policy making and the appraisal of policy instruments. Examples of economic policy tools include natural capital accounting (see chapter 7), cost-effectiveness analysis, cost-benefit analysis and multi-criteria analysis (see chapter 9).

2 See Day (2013) for a more detailed explanation of welfare and exchange values.

Table 3. Classification of environmental policy instruments (UNEP, 2007)

COMMAND-AND- CONTROL REGULATIONS	DIRECT PROVISION BY GOVERNMENT	ENGAGING PUBLIC AND PRIVATE SECTORS	USING MARKETS	CREATING MARKETS
Standards Bans Permits Quotas Zoning Liability Legal redress	Environmental infrastructure Eco-industrial zones or parks Protected areas Recreation facilities Ecosystem rehabilitation	Education Public participation Information disclosure Voluntary agreements Public-private partnerships	Subsidies Taxes User charges Deposit-refund systems Green procurement	Property rights Tradeable permits Offsets Payment for ecosystem services Eco-labelling

3. Impact assessment

Environmental economic methods can be used to quantify and communicate the scale of economic impacts from changes in marine ecosystems. Such information can be included in marine spatial planning (MSP) and environmental impact assessments (EIA). In this chapter, environmental impact assessment, economic impact assessment and risk analysis are introduced.

The Marine Spatial Planning toolkit Section 6.1 specifically addresses the analysis of sector impacts in the context of marine spatial planning.

3.1 Environmental Impact Assessment (EIA)

Environmental Impact Assessment (EIA) is a procedure for ensuring the incorporation of environmental, and where required, social and economic information in sound and well-balanced decision making. EIA is not principally an environmental economic method but may include economic information and is therefore outlined briefly here. EIA is conducted to assess the impacts of planned activities in advance so that measures can be taken to avoid damage to the environment. EIA is sometimes also referred to as Environmental and Social Impact Assessment (ESIA), Integrated Environmental Assessment (IEA) or, particularly in cases where social and economic impacts are also relevant and included in the assessment, Sustainability Impact Assessment (SIA). One of the strengths of EIA as a framework is that it is often anchored in the national legislation and planning processes.

The EIA process involves the following steps:

1. Analysing the likely impact of a decision;
2. Organising public participation and consultation;
3. Developing and comparing alternative options;
4. Reporting the impacts, alternatives and comments from the general public;
5. Taking the report into account when making the final decision;
6. Informing the public about that decision.

Useful resources on conducting EIA are available from:

- The International Finance Corporation (IFC)
- The Netherlands Commission for Environmental Assessment

Conducting EIA involves different forms of stakeholder engagement at various steps in the process. See the toolkit on stakeholder engagement for guidance on this in an LME context.

While EIA is used for assessing environmental impacts of individual development projects, e.g. a seawall, wind farm or port, Strategic Environmental Assessment (SEA) is used at a higher level, for assessing environmental impacts of plans, programmes or policies, e.g. a conservation strategy or a marine spatial plan. The key steps of EIA and SEA are similar but the actual tasks and stakeholders involved can be quite different. Table 4 illustrates the main differences between EIA and SEA.

Table 4: Differences between Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA)

	SEA	EIA
PROCESS	Iterative	Linear
SCREENING	Mostly decided case by case	Projects requiring EIA are often listed
SCOPING	Combination of political agenda, stakeholder discussion and expert judgement	Combination of local issues and technical checklists
PUBLIC PARTICIPATION	Focus on representative bodies	Often include general public
ASSESSMENT	More qualitative (expert judgement)	More quantitative
QUALITY REVIEW	Both quality of information and stakeholder process	Focus on quality of information
DECISION MAKING	Comparison of alternatives against policy objectives	Comparison against norms and standards
MONITORING	Focus on plan implementation	Focus on measuring actual impacts

Source: Netherlands Commission for Environmental Assessment

3.2 Economic impact assessment

Economic impact assessments involve the analysis of direct, indirect and induced economic effects (employment, income, expenditure) resulting from the implementation of a specific project, investment or development. An economic impact assessment measures three types of impact:

1. **Direct** – the direct employment and expenditure that is required to implement the project. For example, a new hotel development would involve employment of construction workers and hotel staff,
2. **Indirect** – the indirect employment and expenditure resulting from project implementation. For example, the hotel construction and operation purchases inputs and services from other sectors (building materials, food, entertainment etc.) that in turn may employ more workers and increase expenditure. These are supply chain linkage effects, and
3. **Induced** – the induced employment and expenditure resulting from higher incomes generated by the project. For example, construction workers and hotel staff spend their incomes on more housing, transportation and food.

The indirect and induced effects (also termed secondary impacts) result in a "multiplier effect" in the sense that the total economic impact of a project may be larger than its direct impacts. A key component of economic impact assessment is the use of "multiplier effects" to measure (indirect and induced) secondary impacts. In other words, a project or development can results in a larger change in economic activity due to knock-on effects in other sectors. Multiplier coefficients or input-output analysis can be used to quantify the scale of multiplier effects in a local or national economy. Multiplier effects can be included as project benefits in economic impact assessment but it is necessary to assess their application cautiously for several reasons:

1. The use of multiplier effects generally relies on the implicit assumption that there are unused or underused resources that will become employed. If this is not the case, their use in a new development may simply result in transfers from one sector to another or displacement effects if resources are simply being drawn away from another use. For example, increased spending in one tourist resort due to a new hotel development may displace spending in an existing resort.
2. Some of the indirect and induced effects of a development may fall outside of the locality (or even country) in which the development takes place. This is referred to as 'leakage'. For example, construction workers and materials may be brought in from other places. Or businesses may be owned by non-residents or international corporations, meaning that any profits from increased business does not accrue to members of the local community.
3. Some indirect and induced effects on demand for goods and services may push up prices and result in local residents and consumers paying more for them.

In addition to carefully considering the use of multiplier effects, economic impact assessments need address other important points to produce credible information:

1. Include full costs of project implementation including opportunity costs and environmental costs. Economic impact assessments tend to focus only on positive economic impacts.

2	Include a counterfactual that describes what would have happened without the specific project under evaluation. This is to avoid the inclusion of changes that were occurring anyway and to measure only additional impacts.
3	Report the durability or persistence of impacts. Persistence can be expressed in terms of number of years over which impacts occur.
4	Assess the extent to which a project displaces other economic activity or employment opportunities.

A useful resource on conducting economic impact assessment in the LME/MPA/ICM context is the Australian socio-economic impact assessment toolkit: A guide to assessing the socio-economic impacts of Marine Protected Areas.

Example Box 3: Employment gains and losses in the Great Barrier Reef Catchment

Being the largest coral reef ecosystem and one of the seven natural wonders of the world, the Great Barrier Reef is truly famous around the globe. This unique marine ecosystem has also drawn the attention of economists, who have estimated the contribution of the Great Barrier Reef Marine Park to the economy of Australia for the period 2004 and 2013. The latest studies estimate the added value of the Great Barrier Reef at AU$5.7 billion, which is predominantly based on tourism benefits (Deloitte Access Economics 2013).

What distinguishes these studies from most other economic valuation studies on marine protected areas around the world is the fact that effort has been put into estimating the employment benefits generated through marine ecosystem services. As shown in Table 5 the direct and indirect employment resulting from the Great Barrier Reef services is estimated at 47,615 and 21,364 respectively.

This economic benefit is particularly interesting in the context of recent plans to expand the port at Abbot Point in northern Australia for the export of coal. This plan is mainly promoted under the premise of boosting the economy and the creation of jobs. The plan involves dredging three million cubic meters of sand and mud to be dumped elsewhere, inside the marine park. Various experts claim this could have a disastrous impact on the reef. As a result, the jobs created through the port expansion may well be lost as a result of the decline of the ecosystem services provided by the Great Barrier Reef.

Table 5. Employment generated through ecosystem services of the Great Barrier Reef

SECTOR	STAY-OVER TOURISM	COMMERCIAL FISHING	RECREATION	RESEARCH	TOTAL
Direct employment	44,851	533	1,767	464	47,615
Indirect employment	19,487	442	1,018	417	21,364
Total employment	64,338	975	2,785	881	68,979

Source: Deloitte Access Economics 2013

3.3 Risk analysis

Risk can be defined broadly as the effect of uncertainty on the objectives of a project, investment or policy. Analysis of risk involves identifying and assessing potential outcomes given that multiple factors that combine to determine the outcomes of projects, investments and policies are variable, often outside the control of decision makers, or not know with certainty. Sources of uncertainty that are relevant to the LME/MPA/ICM context include:

- Events that may or may not occur within a given time period (e.g. storms, floods, oil spills),
- Variability in relevant environmental and economic parameters over time (e.g. sea temperature, precipitation, prices, exchange rates, wages), and
- Current lack of knowledge or understanding of how complex systems function (e.g. fishery spillovers from MPAs, ecosystem responses to climate change).

Risk assessment includes three main considerations:

1. The likelihood of different outcomes. Likelihood can be expressed as probabilities that take a value between 0 and 1, with 0 indicating no chance of a particular outcome and 1 indicating a certain occurrence. Often probabilities are based on historical data but it is necessary that they also reflect existing trends and expected future changes (e.g. increasing storm frequency due to climate change). In the absence of perfect data, models or knowledge, the uncertainties underlying risks are typically estimated based on broad assumptions to ensure that a lack of complete knowledge does not result in an underestimation of true risks. It is advisable to overestimate risks and cover worst-case scenarios given that some negative impacts may be irreversible [3]; (Holsman et al., 2017)
2. Consequences of different outcomes. This involves the assessment of environmental and economic impacts (see chapters 3.1 and 3.2);
3. Welfare impacts of different outcomes. This involves quantifying the monetary value of negative and positive impacts to allow them to be directly compared and included in decision support tools (see chapter 4 on valuation methods and chapter 7 on economic appraisal frameworks).

3.4 Links

Potentially useful resources for identifying, quantifying and mitigating risks to marine ecosystems are:

The International Council for the Exploration of the Seas (ICES) handbook on Marine and coastal ecosystem-based risk management

3 Holsman *et al.* (2017) present a conceptual framework for ecosystem risk assessment (ERA), highlighting its role in operationalizing ecosystem based management (EBM), with specific attention to ocean management considerations.

The Environment Defence Fund (EDF) Comprehensive Assessment of Risk to Ecosystems (CARE) model. The CARE model uses local and expert knowledge to assess the risk to different components of a spatially explicit site from all the potential drivers of change facing that site. Such an analysis can help to direct limited management resources and inform spatially explicit management siting decisions. ➔ http://fishe.edf.org/care-model

Example: Reefs at Risk

An example of a global risk assessment for a marine ecosystem is provided by the World Resources Institute (WRI) *reefs at risk revisited* project. The study developed a detailed spatial assessment of the status of and threats to the world's coral reefs. This information is intended to raise awareness about the location and severity of threats to coral reefs. The results can also be used to identify opportunities for changes in policy and practices protect coral reefs and the benefits they provide to future generations.

The combined impacts of local and global threats are expected to increase over time and lead to more than 90 percent of reef being threatened by 2030.

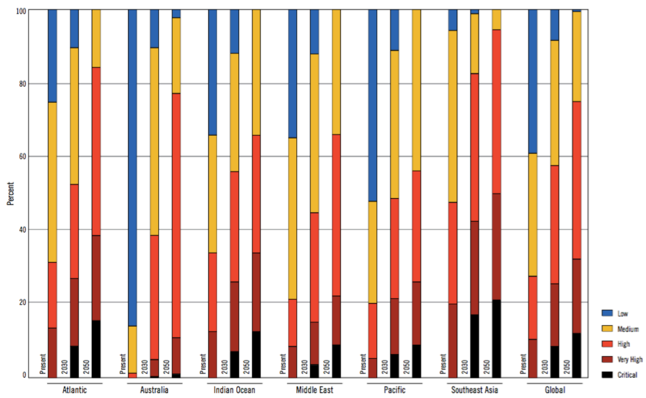

Figure 7: Percentage of reefs at risk by region – present, 2030 and 2050 (Burke et al. 2011).

4. Valuation of ecosystem services

This chapter provides an overview of methods for estimating the value of ecosystem services in monetary units. A separate toolkit developed under GEF IW:LEARN Sub-Component 5.1 is dedicated specifically to methods for valuing ecosystem services in the LME/MPA/ICM context.

The application of economic valuation methods generally involves a high degree of stakeholder engagement, from key informant interviews for identifying important ecosystem services to in-depth surveys of beneficiaries. **›› The Stakeholder Engagement toolkit, Section 4**, provides an overview of stakeholder engagement processes and tools.

4.1 Uses of value information

Information on the economic value of ecosystem services can be useful for a number of different policy and decision making contexts including: advocacy and public awareness raising; appraisal of projects, investments and policies; impact assessment; sustainable financing; and setting compensation for environmental damage.

In the LME context, information on the economic value of ecosystem services derived from a LME and how these values might change in the future can be useful input in the Transboundary Diagnostic Analysis (TDA). The GEF LME:LEARN Project Cycle toolkit Section 3 and **›› Strategic Approach toolkit Section 3** provide detail on the TDA process.

Example Box 5: The total economic value of Bonaire Marine Park

Bonaire is an island in the Caribbean located north west of Venezuela and is formally a special municipality of the Netherlands. Bonaire spreads across 288 km² and is famous for its coral reefs. The entire coastline of Bonaire is protected, with the status of Marine Park established in 1979. The value of Bonaire's ecosystems to tourism has been assessed to be much higher than in other comparable sites. Bonaire is very popular among the diving community and is consistently ranked in the Top 3 of the Scuba Diving Magazine. As a result, the economy of Bonaire relies greatly on dive tourism.

Another distinctive feature of the Bonaire Marine Park is the high non-use value of the marine ecosystem. An extensive survey among citizens of the Dutch mainland revealed a high appreciation of Bonaire's ecosystems, even if these people have no intention of visiting the island. The average annual amount that residents of the Netherlands are willing to pay for nature protection in the Caribbean Netherlands is estimated at around USD 7 per household, which aggregates to a total of USD 60 million. As shown in Figure 8, this constitutes the largest component of the Total Economic Value of Bonaire's ecosystems.

This evidence of the willingness to pay of Dutch mainland citizens for nature conservation in the Caribbean Netherlands built an argument for securing a €7.5 million investment for nature conservation on the three Dutch islands by the Ministry of Economic Affairs. Also WWF Netherlands used the study results to allocate a budget for conservation efforts in the Caribbean Netherlands.

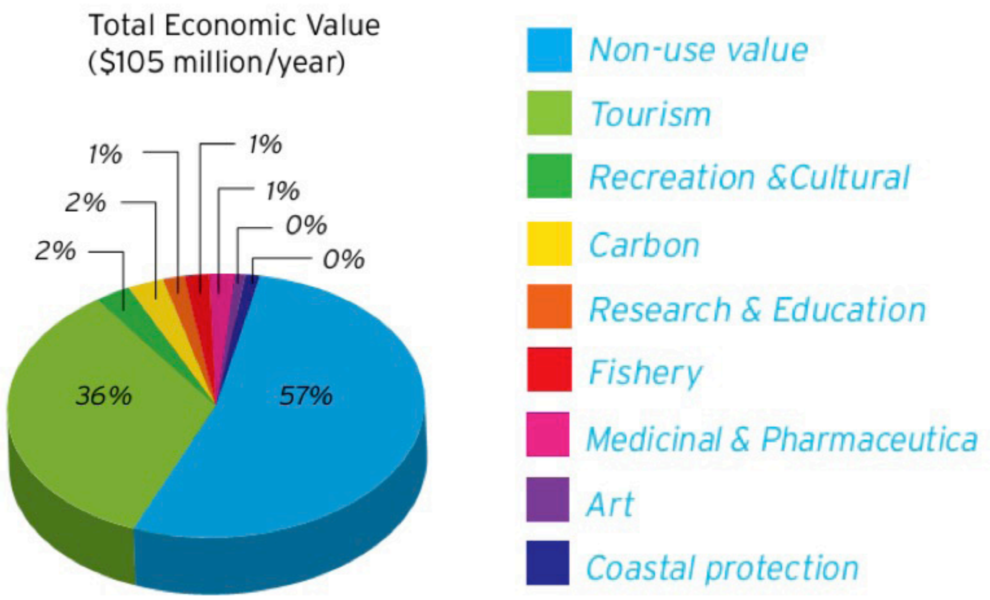

Figure 8: The contribution of non-use values to the Total Economic Value of the ecosystems of Bonaire

4.2 Valuation methods and when to use them

A variety of methods have been developed for estimating the economic value of ecosystem services that are designed to span the range of valuation challenges raised by the application of economic analyses to the complexity of the natural environment. Figure 9 provides a representation of the available economic methods for valuing ecosystem services. We separately introduce methods that produce new or original information generally using primary data (primary valuation methods) and those that use existing information in new policy contexts (value transfer methods).

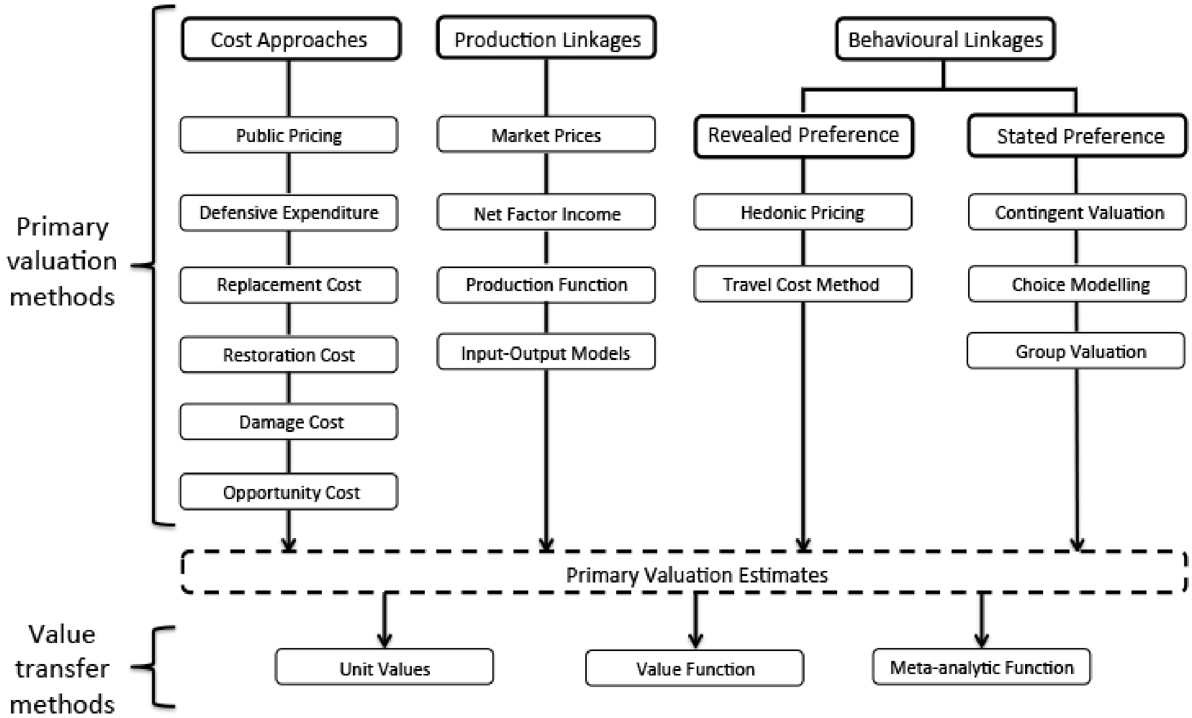

Figure 9: Overview of primary valuation and value transfer methods

Primary valuation methods

Table 6 provides an overview of primary valuation methods, typical applications, limitations and indicates which primary valuation methods can be used to value which ecosystem service. An important distinction to be aware of between primary valuation methods is the difference between revealed preference methods (those that observe actual behaviour of the use of ecosystem services to elicit values) and stated preference methods (those that use public surveys to ask beneficiaries to state their preferences for, generally hypothetical, changes in the provision of ecosystem services). Revealed preference methods may be favoured since they reflect actual behaviour but are limited in their applicability to some ecosystem services. Stated preference methods on the other hand rely on responses recorded in surveys or experiments but are more flexible in their application.

It should be noted that different valuation methods produce different measures of economic value that are not equivalent and cannot necessarily be directly compared. The valuation method, and the measure of economic value that it estimates, will have a substantial bearing on the magnitude of the value estimated. It is therefore important to understand what each measure is and to select a measure that is relevant to the case in hand. There are numerous existing publications that provide guidance on the use of primary valuation methods. A selection of these are listed in Section 4.5.

Table 6: Primary valuation methods, applicability to ecosystem services, examples and limitations (adapted from Table A2, Brander 2013)

VALUATION METHOD	APPROACH	APPLICATION TO ECOSYSTEM SERVICES	EXAMPLE ECOSYSTEM SERVICE	LIMITATIONS
Market prices	Prices for ES that are directly observed in markets	ES that are traded directly in markets	Timber and fuel wood from forests; clean water from wetlands	Market prices can be distorted e.g. by subsidies. Most ES are not traded in markets
Public pricing	Public expenditure or monetary incentives (taxes/subsidies) for ES as an indicator of value	ES for which there are public expenditures	Watershed protection to provide drinking water; Purchase of land for protected area	No direct link to preferences of beneficiaries
Defensive expenditure	Expenditure on protection of ES	ES for which there is public or private expenditure for its protection	Recreation and aesthetic values from protected areas	Only applicable where direct expenditures are made for environmental protection related to provision on an ES. Provides lower bound estimate of ES benefit
Replacement cost	Estimate the cost of replacing an ES with a man-made service	ES that have man-made equivalents	Coastal protection by dunes (replaced my seawalls); water storage and filtration by wetlands (replaced by reservation and filtration plant)	No direct relation to ES benefits. Over-estimates value if society is not prepared to pay for man-made replacement. Under-estimates value if man-made replacement does not provide all of the benefits of the original ecosystem
Restoration cost	Estimate cost of restoring degraded ecosystems to ensure provision of ES	Any ES that can be provided by restored ecosystems	Coastal protection by dunes; water storage and filtration by wetlands	No direct relation to ES benefits. Over-estimates value if society is not prepared to pay for restoration. Under-estimates value if restoration does not provide all of the benefits of the original ecosystem.
Damage cost avoided	Estimate damage avoided due to ecosystem service	Ecosystems that provide storm, flood or landslide protection to houses or other assets	Coastal protection by dunes; river flow control by wetlands; landslide protection by forests	Difficult to quantify changes in risk of damage to changes in ecosystem quality

VALUATION METHOD	APPROACH	APPLICATION TO ECOSYSTEM SERVICES	EXAMPLE ECOSYSTEM SERVICE	LIMITATIONS
Social cost of carbon	The monetary value of damages caused by emitting one tonne of CO2 in a given year. The social cost of carbon (SCC) therefore also represents the value of damages avoided for a one tonne reduction in emissions	Carbon storage and sequestration	Carbon sequestered and stored by protected or restored forests	SCC is a specific application of the "damage cost avoided" method. SCC is characterised by high modeling uncertainties and partial coverage of climate change impacts
Opportunity cost	The next highest valued use of the resources used to produce an ecosystem service	All ecosystem services	The opportunity cost of ecosystem services from a natural ecosystem might be the value of agricultural output if the land is converted to agricultural instead of conserved in a natural state	Measures the cost of providing ecosystem services instead of the benefit
Net factor income (residual value)	Revenue from sales of ecosystem-related good minus cost of other inputs	Ecosystems that provide an input in the production of a marketed good	Filtration of water by wetlands; commercial fisheries supported by coastal wetlands	Tendency to over-estimate values since all normal profit is attributed to the ES
Production function	Statistical estimation of production function for a marketed good including an ES input	Ecosystems that provide an input in the production of a marketed good	Soil quality or water quality as an input to agricultural production	Technically difficult. High data requirements
Input-Output Models	Quantifies the interdependencies between economic sectors in order to measure the impacts of changes in one sector to other sectors in the economy. Ecosystems can be incorporated as distinct sectors	Ecosystem services with direct and indirect use values, particularly inputs into production	Ecosystem inputs into agriculture; or into the tourism sector	Requires substantial data on ecosystem-economy linkages to parameterise connections between sectors
Hedonic pricing	Estimate influence of environmental characteristics on price of marketed goods	Environmental characteristics that vary across goods (usually houses)	Urban green open space; air quality moderated by ecosystems	Technically difficult. High data requirements. Limited to ES that are spatially related to property locations
Travel cost	Estimate demand for ecosystem recreation sites using data on travel costs and visit rates	Recreational use of ecosystems	Recreational use of national parks	Technically difficult. High data requirements. Limited to valuation of recreation. Complicated for trips with multiple purposes or to multiple sites

VALUATION METHOD	APPROACH	APPLICATION TO ECOSYSTEM SERVICES	EXAMPLE ECOSYSTEM SERVICE	LIMITATIONS
Contingent valuation	Ask people to state their willingness to pay for an ES through surveys	All ecosystem services	Biodiversity; recreation; landscape aesthetics; flood risk attenuation	Expensive and technically difficult to implement. Risk of biases in design and analysis
Choice modelling (choice experiment)	Ask people to make trade-offs between ES and other goods to elicit willingness to pay	All ecosystem services	Biodiversity; recreation; landscape aesthetics; flood risk attenuation	Expensive and technically difficult to implement. Risk of biases in design and analysis
Group / participatory valuation	Ask groups of stakeholders to state their willingness to pay for an ES through group discussion	All ecosystem services	Biodiversity; recreation; landscape aesthetics; flood risk attenuation	Risk of biases due to group dynamics

Value transfer methods

Decision-making often requires information quickly and at low cost. New 'primary' valuation research, however, is generally time consuming and expensive. For this reason there is interest in using information from existing primary valuation studies to inform decisions regarding impacts on ecosystems that are of current interest. This transfer of value information from one context to another is called value transfer.

Value transfer is the use of research results from existing primary studies at one or more sites or policy contexts ("study sites") to predict welfare estimates or related information for other sites or policy contexts ("policy sites"). Value transfer is also known as benefit transfer but since the values that are transferred may be costs as well as benefits, the term value transfer is more generally applicable.

In addition to the need for expeditious and inexpensive information, there is often a need for information on the value of ecosystem services at a different geographic scale from that at which primary valuation studies have been conducted. So even in cases where some primary valuation research is available for the ecosystem of interest, it is often necessary to extrapolate or scale-up this information to a larger area or to multiple ecosystems in the region or country. Primary valuation studies tend to be conducted for specific ecosystems at a local scale whereas the information required for decision-making, and indeed for LMEs, is often needed at a regional or multi-national scale. Value transfer therefore provides a means to obtain information for the scale that is required.

The number of primary studies on the value of ecosystem services is substantial and growing rapidly. This means that there is a growing body of evidence to draw on for the purposes of transferring values to inform decision-making. With an expanding information base, the potential for using value transfer is improved.

Value transfer can potentially be used to estimate values for any ecosystem service, provided that there are primary valuations of that ecosystem service from which to transfer values. Value transfer methods have been employed widely in national and global ecosystem assessments, value mapping applications and policy appraisals. The use of value transfer is widespread but requires careful application. The alternative methods of conducting value transfer are described here:

1. Unit value transfer uses values for ecosystem services at a study site, expressed as a value per unit (usually per unit of area or per beneficiary), combined with information on the quantity of units at the policy site to estimate policy site values. Unit values from the study site are multiplied by the number of units at the policy site. Unit values can be adjusted to reflect differences between the study and policy sites (e.g. income and price levels).

2. Value function transfer uses a value function estimated for an individual study site in conjunction with information on parameter values for the policy site to calculate the value of an ecosystem service at the policy site. A value function is an equation that relates the value of an ecosystem service to the characteristics of the ecosystem and the beneficiaries of the ecosystem service. Value functions can be estimated from a number of primary valuation methods including hedonic pricing, travel cost, production function, contingent valuation and choice experiments.

3. Meta-analytic function transfer uses a value function estimated from the results of multiple primary studies representing multiple study sites in conjunction with information on parameter values for the policy site to calculate the value of an ecosystem service at the policy site. A value function is an equation that relates the value of an ecosystem service to the characteristics of the ecosystem and the beneficiaries of the ecosystem service. Since the value function is estimated from the results of multiple studies, it is able to represent and control for greater variation in the characteristics of ecosystems, beneficiaries and other contextual characteristics. This feature of meta-analytic function transfer provides a means to account for simultaneous changes in the stock of ecosystems when estimating economic values for ecosystem services (i.e. the "scaling up problem"). By including an explanatory variable in the data describing each "study site" that measures the scarcity of other ecosystems, in the vicinity of the "study site", it is possible to estimate a quantified relationship between scarcity and ecosystem service value. This parameter can then be used to account for changes in ecosystem scarcity when conducting value transfers at large geographic scales.

These three principal methods for transferring ecosystem service values are summarised in Table 7 together with their respective strengths and weaknesses. The choice of which value transfer method to use to provide information for a specific policy context is largely dependent on the availability of primary valuation estimates and the degree of similarity between the study and policy sites. In cases where value information is available for a highly similar study site, unit value transfer may provide the most straightforward and reliable means of conducting value transfer. On the other hand, when study sites and policy sites are different, value function or meta-analytic function transfer offers a means to systematically adjust transferred values to reflect those differences. Similarly, in the case that value information is required for multiple different policy sites, value function or meta-analytic function transfer may be a more accurate and practical means for transferring values. Using meta-analytic functions that include a parameter for ecosystem scarcity provides a means to account for simultaneous changes in the stock of ecosystem on the value of all ecosystem services (i.e. more accurately "scale-up" ecosystem service values).

Table 7: Value transfer methods, strengths, weaknesses and tier (adapted from Brander 2013)

	APPROACH	STRENGTHS	WEAKNESSES
Unit value transfer	Select appropriate values from existing primary valuation studies for similar ecosystems and socio-economic contexts. Adjust unit values to reflect differences between study and policy sites (usually for income and price levels)	Simple	Unlikely to be able to account for all factors that determine differences in values between study and policy sites. Value information for highly similar sites is rarely available
Value function transfer	Use a value function derived from a primary valuation study to estimate ES values at policy site(s)	Allows differences between study and policy sites to be controlled for (e.g. differences in population characteristics)	Requires detailed information on the characteristics of policy site(s)
Meta-analytic function transfer	Use a value function estimated from the results of multiple primary studies to estimate ES values at policy site(s)	Allows differences between study and policy sites to be controlled for (e.g. differences in population characteristics, area of ecosystem, abundance of substitutes etc.). Practical for consistently valuing large numbers of policy sites.	Requires detailed information on the characteristics of policy site(s). Analytically complex

4.3 Distributional considerations

Distribution of impacts across stakeholders

The distribution of costs and benefits across different groups in society is usually an important criterion in public decision-making and needs to be addressed as part of the assessment process. The allocation of the benefits and costs among different groups within society may well determine the political acceptability of alternative options.

The uneven distribution of costs and benefits has both practical and ethical consequences. In practical terms, it is important to assess the burden of costs and benefits received by local stakeholders, as they often have a strong influence on how successful project implementation will be. It is often the case with the establishment of protected areas that attempting to exclude local stakeholders from accessing an environmental resource will not be successful without sharing the benefits of conservation with them. Understanding who gains and who loses from each policy option can provide important insights into the incentives that different groups have to support or oppose each project. This approach can thus provide useful information in the design of appropriate responses and increase success in implementing projects/plans.

In terms of ethical considerations, the analysis of the distribution of costs and benefits is important to ensure that conservation interventions do not harm vulnerable groups within society. Identifying and estimating the distribution of costs and benefits across different groups is the first step in designing measures to avoid disproportionate or undesirable allocation of impacts, compensation mechanisms, or payment schemes between gainers and losers. A general approach to identifying which groups will be affected by alternative options is through stakeholder analysis. One way of displaying the distributional effects of alternative options is to construct a distributional matrix, which displays the costs and benefits of a policy option, and shows how they are distributed among different socio-economic groups.

Information on the distribution of the impacts of alternative options may be included directly in a MCA as an additional criterion in the analysis, which then contributes to the overall weighted standardised score of each option. It is technically more challenging to include distributional considerations directly in a CBA. Generally, the distributional consequences of alternative options can be provided alongside the outputs of the analysis as additional information for decision-makers to consider.

Spatially distributed impacts

As noted earlier, the decision-making context regarding the management of ecosystem services is often one of spatial targeting. Decisions are being made about where to invest in ecosystem restoration, establish of protected areas, or target financial incentives to change the behaviour of land users. In this case, the spatial correspondence of costs and benefits relevant to the decision is of crucial importance and mapping these inputs is necessary.

The spatial distribution of impacts from alternative policy options may also be of interest to decision makers, particularly where different user groups are located in different areas. The analysis of the spatial distribution of impacts may be seen as an extension of the distributional analysis described in the previous section and may be a useful approach to identifying different societal groups that are impacted by a project. For example, projects that address water management at a river basin level are likely to affect upstream and downstream stakeholders differently – and this should be identified through spatial analysis. Alternative policy options will generally result, not only in different aggregate costs and benefits, but also in the spatial distribution of impacts. If these differences in spatial distribution are considered of importance, they also need to be represented to decision makers.

Temporally distributed impacts

Most policy options will result in impacts not only in the year in which they are implemented but also over a number of years into the future. Both the costs and benefits of a project will therefore have a temporal distribution. It is often the case that projects involve initial investment costs followed by a stream of benefits received over several years in the future. It is important to account for this distribution of costs and benefits over time because people tend to value a benefit or cost in the future less than a benefit or cost now. The practice of accounting for this time preference is called discounting and involves putting a higher weight on current values.

There are two motivations for this higher weighting of current values. The first is that people are impatient and simply prefer to have things now rather than wait to have them in the future. The second reason is that, since capital is productive, a Euro's worth of resources now will generate more than a Euro's worth of goods and services in the future. Therefore, an entrepreneur is willing-to-pay more than one Euro in the future to acquire one Euro's worth of these resources now. In most cases, the discount rate is therefore based on the opportunity cost of capital – the prevailing rate of return on investments elsewhere in the economy, i.e. the interest rate.

The usual way to deal with temporally distributed values is to apply a discount rate to future values so that they can be compared as "present values". Suppose an annual value of an ecosystem service X $ will occur over a period of T years, and a discount rate of r per cent is applied, then the present value of the ecosystem service is:

$$\sum_{t=0}^{T} X / (1+r)^{t}$$

The present value of the value X in any given year with t>0, X/(1+r)t, is smaller than the value X in year t=0. From the equation it can be seen that the higher the discount rate r and the higher the number of years (t), the lower the discounted value of future benefits in any given year.

The choice of the appropriate discount rate remains a contentious issue because it often has a significant impact on the outcome of the analysis (Pearce. 2003, Kahn and Greene 2013) Various respected organisations provide advice on the discount rate to be used. For example, the UK Treasury guidelines recommend a discount rate of 6% for public sector projects while for most environmental and social impact studies 3.5% is recommended.

The Green Book

US Environmental Protection Agency (EPA) website

There is evidence to suggest that people discount the future differently for different goods. If people have lower rates of time preference for environmental goods than for money, a lower discount rate than the interest rate should be used. It is also possible that rates of time preference diminish over time, i.e. that the discount rate declines for impacts in the far future. The choice of discount rate can have a large impact on the findings of an evaluation or valuation study, and should, therefore, be varied in a sensitivity analysis to check how it influences the results.

4.4 Assessing and communicating uncertainty

The magnitude of uncertainty regarding estimated values needs to be quantified and communicated in order to provide an understanding of the robustness of the value information provided. Decision makers can then assess whether the information is sufficiently precise to be considered in making the decision. A balance has to be struck between presenting too little information on the level of uncertainty (e.g. giving the impression of high certainty for a central estimate) and too much information that cannot be taken in (e.g. a table of results for an extensive sensitivity analysis).

Alternative ways to quantify and communicate uncertainties in value transfer include:

1 **Ranges of values.** In cases where multiple primary value estimates are available for the ecosystem service under consideration, the range of values can be presented to give an impression of the variability of unit value estimates.

2 **Distribution of values.** In order to give a more complete picture of the distribution of value estimates, information on the average, median and standard error of the average value can be presented (in addition to information on the range of values). Minimum and maximum values may be 'outliers' and not necessarily representative of the likely values of the ecosystem service.

3 **Confidence intervals.** A confidence interval is an estimated range of values which is likely to include the actual value. The estimated range is calculated from the set of sample data on the ecosystem service value under consideration. Confidence intervals are usually expressed as a range of values within which the actual value lies with a given confidence level or probability.

4 **Sensitivity analysis**. A sensitivity analysis can be used to show how estimated ecosystem service values change as value function parameters, data inputs and assumptions change. A sensitivity analysis involves systematically varying (within plausible ranges) the uncertain inputs to a model to assess how sensitive the results are to those changes. Joint sensitivity analysis (varying more than one parameter at a time) is sometimes also useful if possible changes in parameters are not independent of each other. In this case, scenarios can be developed that describe how multiple parameters might change in combination.

5 **Transfer errors.** The percentage difference between the actual value and the transferred value is called the 'transfer error'. The formula for calculating transfer error is:

Transfer error = (predicted value - observed value) / observed value

For example, a transfer error of 50% means that the predicted value is 50% higher or lower than the observed value at the policy site). Assessments of transfer errors show the difference between the transferred value and the actual value of the ecosystem service. Since in most cases the actual value is unknown, it is generally not possible to compute transfer errors (indeed if we knew the actual value we wouldn't need to use value transfer). Nevertheless, studies that do examine transfer errors (i.e. compare primary and transferred values) provide an indication of how accurate value transfer is in general.

It is evident that in almost all cases the value of ecosystem services will not be estimated with complete certainty. The question, therefore, becomes how much uncertainty is too much? Assessments of the 'size' of uncertainty are important but require careful interpretation and are not comparable across contexts. Arguably, the simplest and most general answer to this question is that the degree of uncertainty becomes unacceptable when a valuation estimate no longer provides information that enables better decisions to be made. For example, if the level of uncertainty is such that the analyst or decision maker can still tell whether, say, benefits (with uncertainty) are still clearly larger or smaller than costs, then that information helps the decision and the level of uncertainty is acceptable.

Different decision making contexts may require different levels of certainty regarding the information that they use. For example, the use of value information for raising general awareness of the importance of ecosystem services arguably does not need to be as accurate as valuation information used in litigation for compensation of damages to ecosystems. A general ordering of decision contexts with respect to their required level of accuracy for value information is represented in Figure 10.

The uncertainty of value transfers and the accuracy requirement of each decision making context should be assessed to determine whether value transfer can provide sufficiently accurate information. In the case that value transfer is judged to be insufficiently accurate, it is advisable to conduct primary valuations of ecosystem services, if resources (data, time, expertise, knowledge) are available.

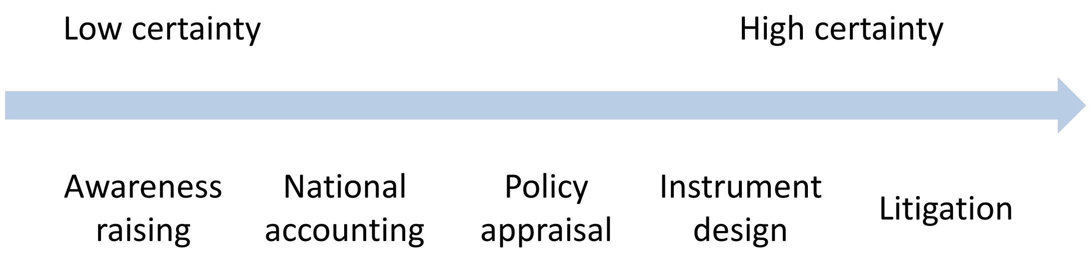

Figure 10. Value certainty requirements for different applications of value information

4.5 Links

- JWRI guidance toolkit on coastal capital
- VALUES Methods for integrating ecosystem services into policy, planning, and practice
- UNEP guidance toolkit on value transfer
- Ecosystem Services Valuation Database (ESVD)
- The Economics of Ecosystems and Biodiversity (TEEB)
- Guidance Manual on Valuation and Accounting of Ecosystem Services for Small Island Developing States
- NEP Guidance toolkit for the valuation of regulating services
- Economic Valuation of Environmental and Resource Costs and Benefits in the Water Framework Directive: Technical Guidelines for Practitioners.
- Guidance for policy and decision makers on using an ecosystems approach and valuing ecosystem services.
- An introductory guide to valuing ecosystem services
- The Measurement of Environmental and Resource Values.
- Handbook on Biodiversity Valuation.
- Economic Valuation with Stated Preference Techniques Summary Guide
- An instrument for assessing the quality of environmental valuation studies.

5. Natural capital accounting

Natural capital is the stock of renewable (e.g. fish, plants, water, wind) and non-renewable resources (e.g. minerals, aggregate, natural gas) that can be used to yield a flow of benefits to people. The benefits provided by natural capital include food, water, energy, recreation, climate regulation, biodiversity, natural flood defence and many raw materials that are used in the production of products that people consume. Natural capital is one of several other forms of capital (e.g. financial, manufactured, social and human capital) that can be combined to produce goods and services for consumption.

Natural capital accounting frameworks aim to provide a structured way of measuring the economic significance of nature that is consistent with existing macro-economic accounts. They can help to identify trends and drivers of ecosystem change within the wider economy and society. By linking to the System of National Accounts (SNA) they can provide comprehensive, integrated and consistent data sets to support national decision-making.

In the context of LMEs, natural capital accounting can be used to quantify the contribution of relevant marine and coastal ecosystem services (e.g. fisheries, coastal protection) to the national or regional economy.

5.1 System of Environmental-Economic Accounting (SEEA)

The System of Environmental-Economic Accounting (SEEA) provides detailed methodological guidance on how to prepare environmental-economic accounts. The SEEA includes three volumes: the Central Framework, Experimental Ecosystem Accounts, and Applications and Extensions.

The SEEA 'Central Framework' (SEEA-CF) was adopted as an international statistical standard for environmental-economic accounting by the United Nations Statistical Commission at its 43rd session in 2012. It has been prepared jointly by the United Nations, the European Commission, FAO, International Monetary Fund (IMF), Organisation for Economic Co-operation and Development (OECD) and the World Bank. It provides an accounting framework that is consistent and can be integrated with the structure, classifications, definitions and accounting rules of the System of National Accounts (SNA), thereby enabling the analysis of the changes in natural capital, its contribution to the economy and the impacts of economic activities on it. SEEA-CF focuses on the stock of natural resources and the flows that cross the interface between the economy and the environment.

The SEEA 'Experimental Ecosystem Accounting' (SEEA-EEA) has been published as a white cover publication in 2013. It aims to measure ecosystem conditions (with a particular focus on carbon and biodiversity) and the flows of ecosystem services into the economy and other human activities. SEEA-EEA offers a synthesis of the current knowledge of ecosystem accounting and serves as a platform for its development at national and sub-national levels. It provides a common set of terms, concepts, accounting principles and classifications, and an integrated accounting structure for ecosystem services and characteristics of ecosystem condition, in both physical and monetary terms. It also includes a chapter on the main challenges and methodological options for the monetary valuation of ecosystems and ecosystem services.

The SEEA 'Applications and Extensions' is currently under development. It will provide compilers and users of SEEA-based environmental-economic accounts with examples showing how the collected information can be used in decision-making, policy review and design, analysis and research.

Furthermore, TEEB Secretariat at UNEP and UN Statistics Division, in collaboration with the CBD Secretariat, have been implementing a project entitled, "Advancing SEEA-EEA in pilot countries", funded by the Norwegian Government, which aims at supporting selected Governments in initiating the testing of SEEA-EEA. The national level activities focus on the assessment of policy priorities, data availability and tools used for ecosystem accounting, stakeholder meetings, the preparation of reports outlining national programmes of work on the advancement of the testing of the SEEA-EEA, as well as relevant national stakeholders to be engaged in the processes. In addition to these national level activities, the project also focuses on facilitating a forum of experts in ecosystem accounting, the preparation of guidance training material and a global strategy for testing the SEEA-EEA, as well as outreach and communication.

5.2 Wealth Accounting and Valuation of Ecosystem Services (WAVES)

WAVES is an initiative of the World Bank to implement green accounting in a critical mass of countries, both developed and developing. The project was launched in October 2010 at the CBD meeting in Nagoya and will last five years. The first two years are the preparation phase to establish the global partnership, to establish a Policy and Technical Experts Committee, and conduct feasibility and planning studies in pilot countries. The implementation phase of the project is from 2012 through 2015. Partner countries currently include: Botswana, Colombia, Costa Rica, Madagascar, the Philippines, Australia. The partners want to take natural capital accounting beyond the SEEA-approved material resources, such as timber and minerals, to include ecosystem services and other natural resources that are not traded or marketed and are therefore harder to measure. That includes the "regulating" services of ecosystems, such as forests for pollination and wetlands for reducing the impact of floods. A Policy and Technical Experts Committee, working closely with the processes set up by the UN Statistical Commission, has been established to take this forward. (Work Bank, 2016)

The country plans are driven by the countries' needs and preferences. Each partner country is developing a road map to take the initiative further. For Botswana and Madagascar, the road map includes developing and implementing macro-indicators such as the Adjusted Net National Income and the Adjusted Net Savings. In addition, the focus in Botswana is on energy resources and energy use, ecosystem-based tourism, and water accounts. In Madagascar the additional focus is on mining, river basins, ecotourism, coastal zone management, and fishery accounts. The other countries have also presented progress reports on the recent second WAVES partnership meeting Washington D.C.: http://go.worldbank.org/O3A2TJSP30

The approach towards the valuation of non-marketed goods and services is spatially-explicit and demand-based. The challenge to use spatially-specific and demand-based value estimates for national accounting is best described In TEEB (2010):

"The power of the national accounting approach is to provide an economy-wide picture of the value of ecosystem services. There are many challenges to incorporating natural capital in a national accounting framework, due to the unique characteristics of natural capital. Many case studies of ecosystem services have been done, but there remain many gaps where services are not covered. In some cases, these gaps can be filled by scaling out or borrowing values from other studies. But the value of many ecosystem services is highly site-specific, which makes gap filling and scaling out a potentially complex undertaking. To address this, country implementation teams will be encouraged to seek and use values from local or sub-national case studies for ecosystem services, and identify reasonable methods for scaling up local value to fill data gaps. Technical advice will also be provided to draw on meta-data analyses, and ecosystem models such as InVEST from the Natural Capital project, ARIES or local models to do this." .

It is also one of the tasks of the Policy and Technical Experts Committee to think about how case study value data can be aggregated, scaled-up and reported in National Accounts (Pittini, 2011).

The WAVES report "Managing Coasts with Natural Solutions: Guidelines for Measuring and Valuing the Coastal Protection Services of Mangroves and Coral Reefs" (World Bank, 2016) specifically provides guidance and recommendations on how the protective services of mangroves and coral reefs can be measured and valued in a manner consistent with national economic accounts and included in other decision-making processes to support planning for development, disaster risk, and coastal zone management.

5.3 Integrated system for Natural Capital and ecosystem services Accounting (INCA)

The European Commission has launched an internal initiative on natural capital accounting (Knowledge Innovation Project: Integrated system for Natural Capital and ecosystem services Accounting – KIP-INCA), in line with the objectives of the 7th Environment Action Programme (EAP) and the EU Biodiversity Strategy. The project aims to design and implement an integrated accounting system for ecosystems and their services in the EU by connecting relevant existing projects and data collection exercises to build up a shared platform of geo-referenced information on ecosystems and their services. This system will be used to derive indicators and assess the economic importance and value of ecosystems and their services, in a manner that is consistent with UN standards on environmental accounting (SEEA-EEA). An innovative outcome of the project is that bio-physical and economic data related to the extent and condition of ecosystems can be integrated in a systematic way, so that they can be aggregated and disaggregated at the required scale, including at national level, to complement figures of economic performance.

The project is structured in two main phases, a feasibility and design phase (until May 2016) and a follow-up implementation phase (running until 2020). The project focuses on establishing an accounting system for the EU level, primarily using EU-wide data sources, thereby contributing the EU layer to the MAES initiative. Member States will be able to link into this system. The main project partners are Eurostat, the European Environment Agency, DG Environment, the Joint Research Centre and DG Research and Innovation.

The KIP will connect relevant existing projects (in particular ESMERALDA) and data collection exercises (such as LUCAS – land use/cover statistics) to enable them to contribute more information about the ecosystem components of natural capital. JRC will be responsible for feeding outputs of ESMERALDA into the KIP. In particular tier-3 physical and economic mapping approaches of ecosystems, ecosystem condition and ecosystem services would be relevant input of ESMERALDA to INCA.

http://ec.europa.eu/eurostat/web/lucas/overview

The ecosystem accounting system will provide maps, tables and accounts and will be designed to support and inform policy development and implementation in the EU and will be established on the basis of MAES, the SEEA EEA and other relevant methodological guidance. The system will be designed so that its data layers and other information outcomes are fit for purpose for policy-makers, analysts and researchers as they prepare various policy evaluations and decisions. It will contribute to better planning and implementation, as well as monitoring of progress towards achieving objectives and meeting communication goals. Examples range from UK work on forest spatially disaggregated accounts, which helped support forest management decisions, to the publication of national natural wealth figures in Canada and Australia to complement economic performance figures. By focussing on ecosystems and their services, this KIP addresses an important gap in terms of knowledge, data and tools, for national accounting and related indicators.

Example Box 6: European Environment Agency (EEA) Simplified Ecosystem Capital Accounts (SECA)

The European Environment Agency has developed a framework for Simplified Ecosystem Capital Accounts (SECA) (Weber, 2011). The basic statistical unit is the Socio-Ecological Landscape Unit (SELU), derived from the Corine land cover maps and additional geo-environmental information on a 1km grid. The main division of landscape units is between mountains, highlands, lowlands, coasts, and rivers. The terrestrial landscapes are subdivided in urban areas, broad pattern agriculture, agricultural associations and mosaics, pastures and natural grasslands, forest tree cover, other dominant natural land cover, and composite land cover.

Within these landscape units, SECA focuses on three groups of services: biomass/carbon production, freshwater production and functional services. The latter measure the capacity or potential of ecosystems to deliver ecosystem services in a sustainable way. A final composite index is the Ecosystem Potential Unit Equivalent (EPUE).

The monetaryvaluation approach of SECA is related to the concept of Consumption of Fixed Capital (CFC). Translated to ecosystems this refers to the depreciation ofecosystem capital. The EEA gives a fewexamples ofthis depreciation: "the cost of keeping below the maximum of 2 degrees global warming target", "REDD (Reducing Emissions from Deforestation and forest Degradation) payments", and "the costs of remediation measures to restore or maintain 'good environmental quality of the river basins' under the Water Framework Directive". Unit costs per EPUE are to be derived by experts from the analysis of real expenditures or costs of restoration programs . "Estimates of unitary costs have to be carried out by ecosystem types/issues/ regions" (Weber, 2011).

5.4 Natural Capital Protocol

The Natural Capital Protocol is a framework specifically designed for private sector business managers to generate actionable information to inform their decisions. The Protocol provides a standardized framework to identify, measure, and value business impacts and dependencies on natural capital. The Protocol is designed to be applicable to any business sector, operating in any geography. It provides a standard framework that covers four stages: "Why", "What", "How" and "What Next", which are further broken down into nine steps that contain specific questions to be answered when integrating natural capital into business processes. The Protocol is iterative to allows users to adjust and adapt their approach as they work through the framework.

Recognising that there are many existing approaches that businesses use to measure and value their impacts and dependencies, develop strategy and engage with stakeholders, The Natural Capital Protocol aims to be complementary to these and provides a standardized framework to help include natural capital in decision-making.

Accounting initiatives such as the UN System of Environmental Economic Accounting (SEEA) are generally implemented by governments or international organisations at the level of political jurisdictions. The Natural Capital Protocol on the other hand is focused at a business decision-making level and can be implemented across multiple political boundaries.

https://naturalcapitalcoalition.org/

6. Economic policy instruments

A range of different policy instruments have been developed and employed to manage the sustainable use of natural resources. Policy instruments are the mechanisms through which policy objectives are pursued. They include direct intervention and regulation by public bodies as well as the promotion of changes in the activities and behaviour of other relevant actors. This chapter provides an overview of economic policy instruments relevant to LME/MPA/ICM and discusses their design.

It is important to recognise that such economic policy instruments are developed and applied within existing policy and legal frameworks. The **Governance toolkit, Section 3**, provides detail on policy and legal frameworks in the LME context. Moreover, the development of policy instruments extensive engagement with stakeholders. The **Stakeholder Engagement toolkit, Section 4** , provides an overview of engagement processes and tools.

6.1 Taxes

Taxes are charges that are paid on inputs, outputs or emissions from production or on the consumption of products. Taxes can have two functions: (1) to raise revenue to fund public expenditure; and (2). to regulate economic activities by increasing their cost. Environmental taxes are levied on inputs or products that have negative environmental impacts, thereby providing incentives for producers or consumers to reduce the use, production or consumption of taxed items. In other words, environmental taxes work by internalising external costs so that the generator of that cost takes it into account in their decision making.

Environmental taxes can potentially deliver a "double dividend" in that they can produce two positive outcomes:

(1) internalise external costs to disincentivise environmentally harmful production and consumption; and (2) generate revenue that can be spent of environmental protection or potentially used to reduce other forms of tax that may distort positive economic behaviour (e.g. income tax).

In the LME context, there may be a case for advocating taxes on resource use and polluting activities within the LME to both partially restrict

6.2 Subsidies

A subsidy is a payment from the government to an economic agent to promote a particular activity. Environmental subsidies can be used to promote production or consumption that reduces negative impacts to the environment. Environmental subsidies can take a number of different forms: direct subsidies for environmental improvements; production subsidies with environmental pre-conditions; tax breaks such as capital allowances for environmental investments; tax rebates, grants or loans for environmental investments; financial support for advice services or voluntary initiatives; tax credits that reduce a person's liability to pay an environmental tax if they have funded an approved environmental project.

Subsidies are widely used to promote economic development and support specific sectors. This includes many industries operating in or impacting on the marine environment (e.g. fisheries, energy, agriculture). In the case of fisheries, subsidies can take the form of reduced prices for fuel and equipment, or the provision of infrastructure (e.g. ports) and processing facilities. While this may be benefit the operators within the targeted sector, it is widely recognised that subsidized activities can have unintended environmental consequences through negative externalities. The design of subsidies therefore needs to include an assessment of their wider impacts and measures to mitigate negative external costs. It is also advisable that subsidies are time limited to avoid permanent dependence on government support, for example to cover periods of transition to new technologies or regulations.

6.3 Tradable permits and quotas

Tradable permits or quotas are used to control the overall level of a particular activity, type of pollution or the use of a resource but allow individual agents to buy or sell permits in order to ensure that they are allocated to the highest valued use. This form of policy instrument is also referred to as "cap-and-trade". In the context of fisheries, the term "individual transferable quota" is used. The steps in designing a tradable permit system are:

1. Set limit for total emissions or use of resource equal to an optimal/ sustainable level (for each sector, region, period),
2. Make initial allocation of permits to polluters/resource users,
3. Allow permits to be traded between polluters/resource users,
4. Monitor actual emissions/resource use by each polluter/resource user, and
5. Impose penalties if emissions/resource use exceed the amount of permits held.

The advantages of using tradable permits to manage the use of environmental resources are: (1) setting a total limit ensures that use does not exceed safe or sustainable levels (this is not guaranteed when using environmental taxes); and (2) allowing permits to be traded ensures that they are allocated to the users that gain the highest value from their use (i.e. ensures efficiency).

Challenges in designing a tradable permit system are: (1) the initial allocation of permits can determine the distribution of returns across participants within the sector; an auction of permits may be seen as a fair or neutral initial allocation but does not reflect historical use of the resource; (2) permits may affect competition within the sector by enabling a small number of firms to gain market (monopoly) power or to behave strategically (e.g. prevent the entry of new firms), and (3) in the case that the specific location and timing of emissions/resource use is relevant to its impact or sustainability, it may be necessary to introduce restrictions on where and when permits can be redeemed.

In the case of fisheries management, individual transferable quota (ITQ) programs allocate shares of a total allowable catch (TAC) to individual fishers, entities or vessels. Such systems allow more individual flexibility in decisions regarding when to fish and what technology to use (in comparison to fishing effort restrictions).

A useful resource for designing ITQ programs is the Environmental Defence Fund (EDF) catch share design manual.

6.4 Area based user rights

An alternative approach to quota based user rights such as individual transferable quotas (ITQs) is to allocate a share of the harvestable area for a resource to each user. In the case of fisheries management this is termed "territorial use rights for fishing" (TURF).

TURFs allocate exclusive rights to harvest one or more target species in a specified area to groups or individuals. They are usually managed by an organized cooperative of fishermen and set appropriate controls on fishing activities. The use of TURFs is most applicable for target species that are not highly mobile and remain within the specified areas.

Environmental Defence Fund (EDF) catch share design manual also provide guidance on designing TURFs and a number of example applications.

6.5 Protected areas

Protected area is defined by the International Union for the Conservation of Nature (IUCN) as "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" and the Convention on Biological Diversity as "a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives".

Protected areas (PAs) include national parks, wilderness areas, community conserved areas, nature reserves and marine protected areas (MPAs). Designation of PAs has been one of the principal approaches for biodiversity conservation. The IUCN has developed a categorisation of protected areas based on their management objectives. Table 8 provides a summary of this classification. By managing activities and the exploitation of resources within areas of high biodiversity, PAs provide a means to protect biodiversity and enhance the provision of other ecosystem services. They also play a role in mitigation of and adaptation to climate change through the storage of carbon and regulation of micro-climates, water flows and storm damage. Effectively managed networks of protected areas have been recognised as important instruments in achieving the objectives of the Convention on Biological Diversity and the Sustainable Development Goals.

Challenges associated with the use of PAs as a biodiversity conservation tool include the extent to which planned protection is implemented and the potential conflicts between biodiversity conservation objectives and the use of resources by local communities.

The **›› Governance toolkit, Section 5.5.**, provides further information on capacity needs and good practices for the implementation of MPAs.

The **›› Strategic Approach toolkit Section 5** also provides information on best practices in MPA implementation.

Table 8. IUCN Protected Area Management Categories

CATEGORY		MAIN OBJECTIVE
IA	Strict Nature Reserve	Managed mainly for science
IB	Wilderness Area	Managed mainly to protect wilderness qualities
II	National Park	Managed mainly for ecosystem protection and recreation
III	Natural Monument	Managed mainly for conservation of specific natural features
IV	Habitat/Species Management Area	Managed mainly for conservation through management interventions
V	Protected Landscape/Seascape	Managed mainly for landscape/seascape conservation and recreation
VI	Managed Resource Protected Area	Managed mainly for the sustainable use of natural ecosystems and resources

Example Box 7: Enhanced management of marine parks, Malaysia

This case study describes the "Conserving Marine Biodiversity through Enhanced Marine Park Management and Inclusive Sustainable Island Development" project, implemented by the Government of Malaysia (GoM) in partnership with the United Nations Development Programme (UNDP) Malaysia, and supported by the Global Environment Facility (GEF).

The project covered three demonstration marine parks in Malaysia: Pulau Redang, Pulau Sibu-Tinggi, and Pulau Tioman. The total project financing incurred was approximately. The project, which ran from 2007-2013 with a budget of US$ 4.13 million, was aimed at:

- Widening the existing development planning process in order to support marine ecosystem management as well as sustainable tourism through stakeholder involvement;
- Strengthening the capacity of the marine parks management system in Peninsular Malaysia and to ensure effective enforcement of marine park regulations at three project sites; an
- Enabling an influential advocacy framework for the conservation of marine biodiversity supported by a raised level of awareness of the importance and benefits of marine biodiversity.

The project resulted in the following benefits particularly related to areas of awareness raising, pollution control, protected areas management and respect of traditional knowledge:

- Awareness and livelihood impact: Through the project's awareness programs such as snorkel guide training, advocacy group set up resulted in greater ownership and appreciation of the biodiversity values of the marine protected areas (MPAs) among the local communities. In addition, direct training and programs such as business courses, English language courses, lessons to fix and maintain boats, training certificates that enabled the communities to be legally recognized as boatmen elevated their livelihood options and opportunities.
- Pollution control: Awareness raising programs by the project and exchange visits brought about the inspiration and push for the local community to clean up their house reef which was then transformed into a site that could support snorkeling activities.
- Protected areas management: The project included the development of protected areas management plan to support better management of MPAs. At the same time, the project raised the enforcement capacity of the Department of Marine Park.
- Respect of traditional knowledge and involvement of local communities: The project developed mechanisms that enabled stakeholder participation and engagement at the local, state and national level. It enabled community perspectives to be channelled to decision makers and planners.

6.6 Certification and labelling

Product labelling can be used to indicate the environmental and social characteristics of goods and services. Certification and labelling of goods and services with positive environmental characteristics enables markets to develop for such products, in which consumers can fulfil their preferences for environmental sustainability and producers can gain a price premium or market share. Certification and labelling addresses one of the difficulties in establishing markets for environmentally friendly products, namely that consumers are otherwise unaware of (or cannot trust claimed) differences between the production processes of products. In other words, it addresses a market failure due to imperfect and asymmetric information held by producers and consumers.

The main elements in a certification and labelling system are: (1) setting environmental and social criteria for the production process; (2) a system of third party verification of compliance with the criteria; (3) ensuring credibility and trust of the process and label; and (4) promoting consumer recognition of the label.

6.7 Links

Examples of certification and labelling systems that are relevant in the LME/MPA/CZM context are:

- Marine Stewardship Council (MSC)
- Aquaculture Stewardship Council (AFC)

6.8 Trade restrictions

Legal restriction on the use or trade of wildlife products is one of the main policy instruments for protecting biodiversity. Demand for wildlife products is diverse and encompasses food, medicine, skins, ornaments, timber and live specimens. The demand for such products is generally observed to increase with population, income and tourism and drives the likelihood that species become endangered or even extinct. Controlling the use of endangered species through legal bans is a direct measure for protection and requires strong institutional capacity for monitoring and enforcement. Illegal trade in endangered species is observed to continue in cases where enforcement is weak and/or demand and prices for wildlife products remain high. Poaching is arguably the most serious direct threat to many of the most endangered species.

Regarding international trade in endangered species, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between governments established to ensure that international trade in specimens of wild animals and plants does not threaten their survival. There is a recognised need for international cooperation to safeguard wildlife that is traded internationally in order to coordinate regulations and monitoring. CITES accords varying degrees of protection to more than 35,000 species of animals and plants.

CITES works by controlling international trade in selected species. All import, export, re-export and introduction from the sea of species covered by the Convention has to be authorized through a licensing system, which is administered by a designated Management Authority in each country that is a Party to the Convention. The species covered by CITES are listed in three Appendices: Appendix I includes species threatened with extinction for which trade is permitted only in exceptional circumstances; Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid over-use that would threaten their survival; Appendix III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade.

Convention on International Trade in Endangered Species of Wild Fauna and Flora

The World Trade Organisation (WTO) rules contain a number of provisions relating to Illegal, Unreported, and Unregulated (IUU) fishing, including on subsidies that may promote IUU.

6.9 Sustainable financing mechanisms

Sustainable financing mechanisms include a wide range of approaches for raising long term funding flows for environmental management, as opposed to conventional donor or project financing that is usually time limited. Sustainable financing mechanisms include conservation trust funds (CTF), debt for nature swaps (DNS), green bonds, payments for ecosystem services (see section 8.9), and biodiversity offsets (see section 8.10). Here we briefly introduce CTFs and DNS. The UNDP provides an extensive list of options for financing sustainable development:

Financing Solutions for Sustainable Development

The importance of sustainable financing to LME governance is specifically addressed in **Section 2.4 of the Governance toolkit**.

Conservation Trust Funds (CTF) or Environmental Trust Funds are generally designed as independent grant-making institutions that mobilize and manage financial resources for environmental purposes, such as biodiversity conservation, climate adaptation and mitigation.

CTFs can be structured as endowment funds (allocating a share of the income generated by the "endowment", which is usually composed of stocks or other revenue generating assets), sinking funds (disburses a share of its capital each year over a defined period of time, until it sinks to zero) or revolving funds (replenished or augmented on a regular basis, usually through government contributions).

Debt-for-nature swaps (DNS) involve debtor governments committing to invest in conservation and/or climate change adaptation or mitigation in return for a reduction or cancellation of debt on the part of creditors. Such arrangements have also been established in the form that creditors agree to sell the debt they hold to a third party (e.g. a conservation organisation) for a discounted price.

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- Debt for Nature Swaps
- Conservation Finance Alliance's set of practice standards for CTFs
- OECD report on scaling up finance mechanisms for biodiversity

6.10 Payments for Ecosystem Services

Payment for Ecosystem Services (PES) is a relatively new policy instrument in resource conservation that establishes a mechanism through which ecosystem service beneficiaries can compensate service providers (Kumar and Thiaw, 2013). PES schemes are based on the principle that people located in ecosystems that provide the services (providers) should be compensated for the continuous provision of such services, while the people who benefit (beneficiaries) from ecosystem services should pay for the protection of such ecosystems.

The term "payments for ecosystem services" (PES) covers a broad set of mechanisms through which incentives for the provision of ecosystem services are established. In a PES scheme, providers of an ecosystem service (e.g. upstream farmers who conserve forests that control water flow) are incentivized to provide that service through some form of payment or compensation, which may be paid by the beneficiaries of the service (e.g. downstream farmers that benefit from lower exposure to flooding). PES schemes attempt to provide incentives for the continued or enhanced provision of services and address the commonly observed problem that markets do not exist for ecosystem services. It is the creation of incentives that is crucially important since the provider of an ecosystem service may otherwise be better off using the ecosystem resource in another way (e.g. an upstream farmer might convert forest area to agricultural land).

PES has been defined narrowly as voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services.

Other definitions have been stated more broadly, for example as a simple transfer of resources between social actors, which aims to create incentives to align individual or collective land use decisions with social interest in the management of natural resources. This broad definition allows for the inclusion of compulsory transactions, payments in kind rather than money (e.g. infrastructure development, education, technical assistance, tenure security), and relaxes the technically challenging condition that the ES provider is shown to ensure the provision of the service.

One of the main attractions of PES as a policy instrument is that it can in principle be self-financing in the case that payments by beneficiaries cover all associated costs (transaction costs as well as opportunity costs of the provider of ecosystem services). A further attraction of this policy instrument is that it can in principle result in an efficient allocation of resources. In theory, payments for ecosystem services will continue up until the point at which the marginal costs of providing them (i.e. the value of the foregone use of those resources to the provider) equals the marginal benefit (i.e. to value of the ecosystem service to the beneficiary).

The observed disadvantages of this policy instrument are the high transaction costs involved in establishing and operating a PES scheme, the institutional requirements for setting, collecting and disbursing payments, and the information requirements to monitor the activities of participants. Few PES schemes have proven to be financially sustainable in the long term after initial funding, often from international donors, has ended.

6.11 Biodiversity offsets, banking and trading

Biodiversity offsets are conservation actions intended to compensate for the unavoidable harm to biodiversity caused by development projects, so as to ensure no net loss of biodiversity. Such conservation actions can be on-site or off-site, and include the restoration or creation of areas of similar habitat to that which is harmed or destroyed.

Biodiversity offsetting is predominantly used by planning authorities and developers to prevent biodiversity loss and, in some cases, produce gains in biodiversity. Biodiversity offsetting involves using qualitative and quantitative measures to determine the amount, type and quality of habitat that is likely to be affected by a proposed project. Biodiversity offsetting can also involve estimating the cost of replacing damaged biodiversity by calculating the cost of creating the same amount, type and quality of habitat at other locations.

Biodiversity banking, also known as biodiversity trading or conservation banking, is a process through which gains in habitat and biodiversity can be reliably measured and traded for the purpose of offsetting losses in biodiversity elsewhere. The term "banking" is used to refer to the way offsets are created and approved prior to development and biodiversity loss taking place. The resulting conservation benefits are "banked" with the regulator and later sold as offsets to future development projects. One of the aims of banking is to avoid any temporal loss of ecosystem benefits.

Biodiversity offsets are generally viewed as a secondary conservation measure to be used in cases where direct protection of biodiversity is not feasible. In other words, developers are expected to first seek to avoid and minimise harm to biodiversity before they contemplate the use of offsets. One of the challenges involved in using biodiversity offsets as an effective conservation policy instrument is ensuring that the habitat that is created or restored is genuinely equivalent in terms of biodiversity to that which is destroyed. Further challenges are associated with monitoring and the permanence of restored habitats.

It is advisable that biodiversity offsetting is only used after all other options in the mitigation hierarchy have been considered and no alternatives are available. Avoidance of biodiversity loss is the first and most important step in the mitigation hierarchy. Biodiversity offsets should not be used to circumvent responsibilities to avoid and minimise damage to biodiversity, or to justify projects that would otherwise not happen.

Example Box 9: Policies to secure food and livelihoods in the Coral Triangle

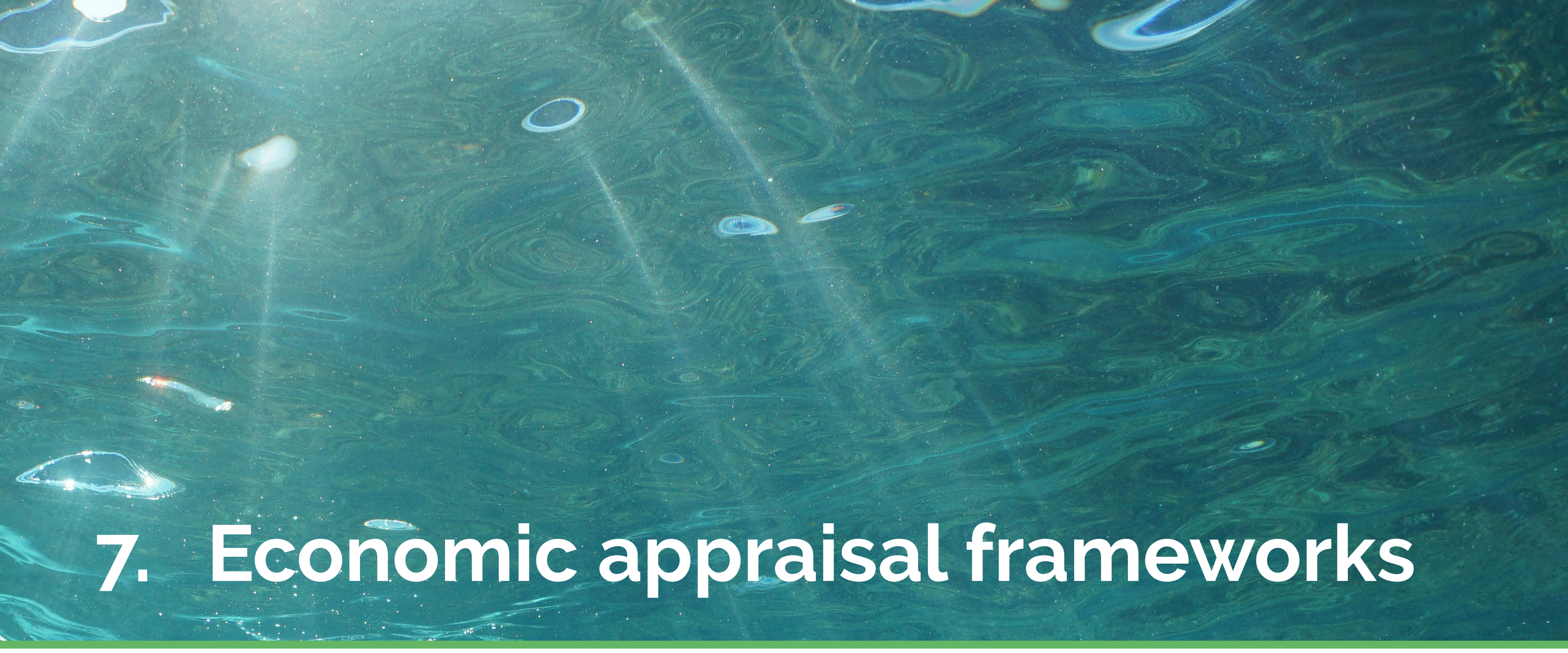
The Coral Triangle's natural wealth directly sustains more than 130 million people living along the coasts of this 6 million square-kilometer ocean expanse in Asia-Pacific. The annual estimated retail value of the trade in live reef food fish, one of the most lucrative and distinctive of the region's reef-based fisheries is USD 1 billion. Indonesia, the Philippines and Papua New Guinea are among the top 10 tuna producing countries in the world. The value of tuna exports from these three countries, plus Malaysia and Solomon Islands, is estimated to be close to USD 1 billion. The annual value of nature-based tourism in the Coral Triangle is estimated to be worth USD 12 billion. All these benefits rely on healthy coastal and marine habitats through the effective protection and management of key areas that are vital for people's food security, livelihoods, and economic stability.

To ensure that this region's natural capital is safeguarded, the governments of the six countries in the Coral Triangle – Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands and Timor-Leste – came together in 2007 to form a multilateral partnership now known as the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF). The CTI-CFF is an example of a regional framework under which governments, private sector, civil society, donors, and development partners collectively aim for the sustainable management of coastal and marine resources in the region. In 2012, the CTI-CFF endorsed a Coral Triangle Marine Protected Area System (CTMPAS) Framework and Action Plan, which contains criteria for the effective management of MPAs and guides the development of a system of MPAs that addresses multiple issues including biodiversity conservation, fisheries management, and climate change adaptation. The CTMPAS is a system of prioritized individual MPAs and networks of MPAs that are connected, resilient, and sustainably financed. These MPAS and networks are designed to be able to generate significant income, livelihoods, and food security benefits for coastal communities, as well as to conserve the region's rich biological diversity.

In 2014, the Tubbataha Reefs Natural Park in the Sulu Sea, in the Philippines was identified as a flagship site for the CTMPAS. Established in 1988, this 970 square-kilometer area is a nationally designated no-take MPA – the largest in the Philippines. Governance incentives have made Tubbataha successful over the years which include:

- **Green marketing** of products and services from the MPA through dive tourism - generating $80,000 to $110,000 a year from conservation fees which support park management, local community livelihoods, local infrastructure and the improvement of public facilities,
- **Economic compensation** for foregone profits to restricted users (i.e., local fishers),
- Public **communication, education, and awareness** raising activities,
- Alignment with international, regional, national, and local **regulatory obligations** that require effective MPA conservation and an effective judicial system,
- **Participative governance** structures and processes; transparent participation and decision-making processes, and
- **Equity and stewardship** strategies that imply sharing of tourism revenues as a compensatory mechanism and co-ownership of the vision to conserve Tubbataha and take pride in it.

Monitoring for the last 15 years in Tubbataha has shown that the live coral cover has been stable at 45-50% after the bleaching of 1998, when coral cover declined by about 22%. Fish biomass, similarly, fluctuates on a yearly basis but has an increasing trend and for the last decade has remained stable at 200 Mt/sq km, which is four times the fish biomass of the average healthy reef in the country. Commercially important species are growing into maturity thus indicating that spawners are protected in the site. This seeds the fisheries in the greater Sulu Sea where the Park is located.



7. Economic appraisal frameworks

Making decisions between alternative investments, projects or policies that affect the provision of ecosystem services often involves weighing up and comparing multiple costs and benefits that are measured in different metrics and are incurred at different locations and points in time. For example, the establishment of a new marine protected area might involve costs in terms of the purchase of coastal land, compensation of local communities, and on-going maintenance and enforcement costs; and benefits in terms of biodiversity conservation, recreational use and enhanced fish stocks. These costs and benefits are likely to be measured in different units, be incurred at different locations by different groups of stakeholders, and have different time profiles. Organising, comparing and aggregating information on such a complexity of impacts; and subsequently choosing between alternative options with different impact profiles requires a structured approach. Economic methods for assessment, evaluation or appraisal of complex decision contexts provide systems for structuring the information and factors that are relevant to a decision.

There are a number of economic assessment methods available to help decision makers to structure the information and factors that are relevant to a decision and to select between alternative investments, projects or policies. The choice of which assessment method to use will largely be determined by the type of decision problem and the availability and nature of information related to each potential option. To understand the differences between economic assessment methods, we describe the procedural steps of each approach, which are often comparable yet differ in subtle ways.

- For decisions that involve selecting between options to achieve a single specific goal (e.g. meeting a specified ecological standard, achieving a targeted coverage of protected area) and where all costs can be expressed in monetary terms, the c**ost-effectiveness analysis** (CEA) method can be used. This approach therefore does not involve any assessment of what the benefits are of meeting the objective but only compares alternative options in terms of their costs.

- When all the impacts of alternative options can be quantified in monetary terms, the most common economic assessment method is **cost-benefit analysis** (CBA). This assessment method involves summing up the value of the costs and benefits of each option and comparing options in terms of their net benefits (i.e. the extent to which benefits exceed costs).

- In the situation that the relevant criteria (costs and benefits) to the decision cannot be expressed in monetary values, but can only be expressed in other units or in qualitative terms (i.e. impacts can be ranked in order of importance), **multi-criteria analysis** (MCA) is a useful assessment method.

It should be noted that CEA, CBA and MCA are general economic assessment methods that can be applied to help select between alternative investments, projects and policies. In this toolkit the focus is on supporting decision-making regarding LME/MPA/ICM. Although the main steps in the assessment methods remain relevant, the nature of ecosystem-related decisions may require emphasis on specific types of input, particularly spatial analysis. The decision-making context regarding the management of ecosystem services is often one of spatial targeting or optimisation. Decisions are being made about where to invest in ecosystem restoration (e.g. CBD Aichi Target 11 that 10 per cent of coastal and marine areas are conserved through protected areas and other effective area-based conservation measures), or target financial incentives to change the behaviour of resource users. In such cases, the spatial correspondence of costs and benefits relevant to the decision is of crucial importance and mapping these inputs is a necessary step in the assessment process. The **Marine Spatial Planning toolkit** provides guidance on spatial assessment tools – see section 5.8.

7.1 Cost-Effectiveness Analysis (CEA)

Cost-effectiveness analysis (CEA) involves identifying the lowest cost option to achieve a given objective.[4] CEA is an applicable assessment method for decisions that involve selecting between alternative measures or technologies to achieve a single specific goal (e.g. meeting a specified ecological standard, supplying a specified quantity of clean water, or sequestering a targeted quantity of carbon) and for which all costs can be measured in monetary terms.

The steps in conducting a CEA are take the following sequence, but there may be feedback loops between steps during the process.

- Step 1: Identify the environmental objective(s) involved (target situation).
- Step 2: Determine the extent to which the environmental objective(s) is (are) met.
- Step 3: Identify sources of pollution, pressures and impacts now and in the future over the appropriate time horizon and geographical scale (baseline situation).
- Step 4: Identify measures to bridge the gap between the reference (baseline) and target situation (environmental objective(s)).
- Step 5: Assess the effectiveness of these measures in reaching the environmental objective(s).
- Step 6: Assess the direct (and if relevant indirect) costs of these measures.
- Step 7: Rank measures in terms of increasing unit costs.
- Step 8: Determine the least cost way to reach the environmental objective(s) based on the ranking of measures .This approach therefore does not involve any assessment of the benefits of meeting the policy target but only compares alternative options in terms of their costs. As such, CEA is a relatively straightforward assessment method to apply and is relevant to decision contexts in which a specific policy target has been set. It does not, however, provide an indication of the magnitude of changes in societal welfare resulting from implementing policy options (i.e. whether society is better or worse off as a result of the decision).

4 Note that the term "cost-effective" is often used to describe investment or policy options that result in a gain in efficiency or, equivalently, for which benefits exceed costs. A "cost-effectiveness analysis", however, only involves ranking options that achieve a given target in order of their cost.

In practice, this economic assessment method is not frequently used in the context of managing ecosystems due to the complex and multifunctional nature of ecosystem service provision. It is generally not the case that a single specific goal for ecosystem service provision can be set and it becomes necessary to consider the multiplicity and variability of benefits derived from alternative options.

7.2 Cost-Benefit Analysis (CBA)

Cost-benefit analysis (CBA) is the most commonly used economic assessment method for evaluating and comparing investments, projects and policies.

It is important to recognise the difference between a CBA that is carried out from the perspective of society as a whole and CBA that is conducted from the perspective of an individual, group, or firm. If applied from this latter perspective, CBA is generally used to determine the financial return of private investments. This private application is commonly known as a 'financial CBA'. Alternatively, government departments apply CBA as the standard tool for evaluating investments, projects and policies from the perspective of society as a whole. This so-called 'extended CBA' is used as a method in which the societal costs and benefits of alternative options are expressed and compared in monetary terms. The extended CBA provides an indication of how much a prospective project or investment contributes to social welfare by calculating the extent to which the benefits of the project exceed the costs – essentially society's 'profit' from a project. In this application, the CBA provides a framework into which monetised ecosystem service values can be integrated.

The main steps in performing a CBA are presented in Figure 11. These steps are described below:

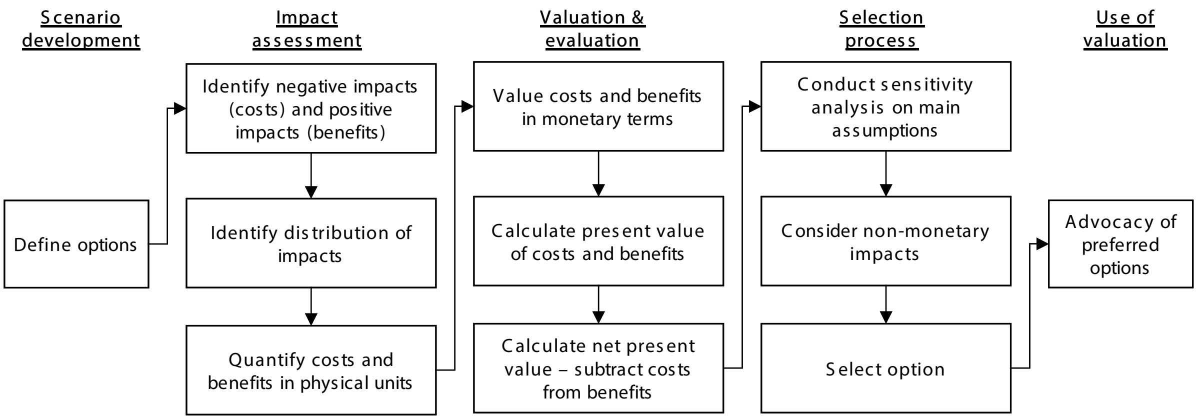


Figure 11: Methodological steps in cost-benefit analysis (Brander and van Beukering, 2015)

The first step in a CBA is to identify the alternative options or alternatives to be considered. The options under consideration will generally be specific to the particular problem and context, but may include investments, projects, policies, development plans etc.

The impact assessment in a CBA starts with the identification of the complete set of negative impacts (costs) and positive impacts (benefits) related to the policy or intervention options under consideration. This includes costs and benefits accruing to all affected groups and individuals (not just those involved in the project development) and costs and benefits that are incurred in the future. It is important to describe the geographical and temporal boundaries of the analysis. This is especially crucial for ecosystem services impacts since effects emerging from ecosystem change often show major variations in time and space. The final step in the impact assessment phase is to quantify each cost and benefit in relevant physical units for each year in which it occurs. Estimating changes in ecosystem services requires specific expertise and models on ecological, hydrological and climatic processes.

To conduct a CBA, all of the quantified positive and negative effects need to be expressed in monetary units. In cases where costs and benefits are not directly observable in monetary terms in well-functioning markets (as is the case for many ecosystem services), estimates need to be generated using non-market valuation methods or value transfer (see Chapter 4).

The economic performance of each alternative option can be calculated in three different ways:

1. The net present value (NPV) of each option is calculated by subtracting the present value costs from present value benefits. A positive NPV indicates that implementing a project will improve social welfare. The NPVs of alternative investments can be compared in order to identify the most beneficial project;
2. The benefit cost ratio (BCR) is the ratio of discounted total benefits and costs, and shows the extent to which project benefits exceed costs. A BCR greater than 1 indicates that the benefits of a project exceed the costs;
3. The internal rate of return (IRR) is the discount rate at which a project's NPV becomes zero. If the IRR exceeds the discount rate used in the analysis, the project generates returns in excess of other investments in the economy, and can be considered worthwhile.

A final step in a CBA is to conduct sensitivity analysis to check the robustness of the conclusions to the assumptions made. Another element is to estimate whether or not the omission of certain costs and benefits that cannot be monetised affects the decision result.

An important drawback of CBA is the requirement that all costs and benefits need to be expressed in monetary terms. Although a range of economic valuation methods are available to estimate values for marketed and non-marketed ecosystem services, there are still considerable limitations to the accuracy of estimated value in some cases. Furthermore, the application of non-market valuation techniques can be expensive and time consuming. For these reasons it may not be possible to estimate monetary values for some costs and benefits and they cannot be entered into a CBA. In some cases, the omitted impacts can be significant and therefore alternative evaluation methods are needed.

Example Box 10: Cost-Benefit Analysis of expanding global marine protected areas

Currently, 3.4% of global marine area is designated as marine protected area (MPA), with 0.59% established as no-take MPAs. The location of existing MPAs is represented in Figure 1. The Convention on Biological Diversity (CBD) Aichi Target 11 and the Durban Action Plan call for an expansion of MPA coverage to 10% and 30% of global marine area respectively. To assess the economic rationale for MPA expansion, Brander *et al.* (2015) conduct a cost-benefit analysis to estimate the net benefits of expanding global marine protected areas (MPAs) to 10% and 30% coverage of total marine area. The study developed a set of six mapped scenarios for the global expansion of MPAs (see Figure 12). The scenarios vary along two dimensions: 1. The coverage of MPAs as a proportion of total marine area; 2. The characteristics of target locations for MPAs in terms of biodiversity and degree of human impact.

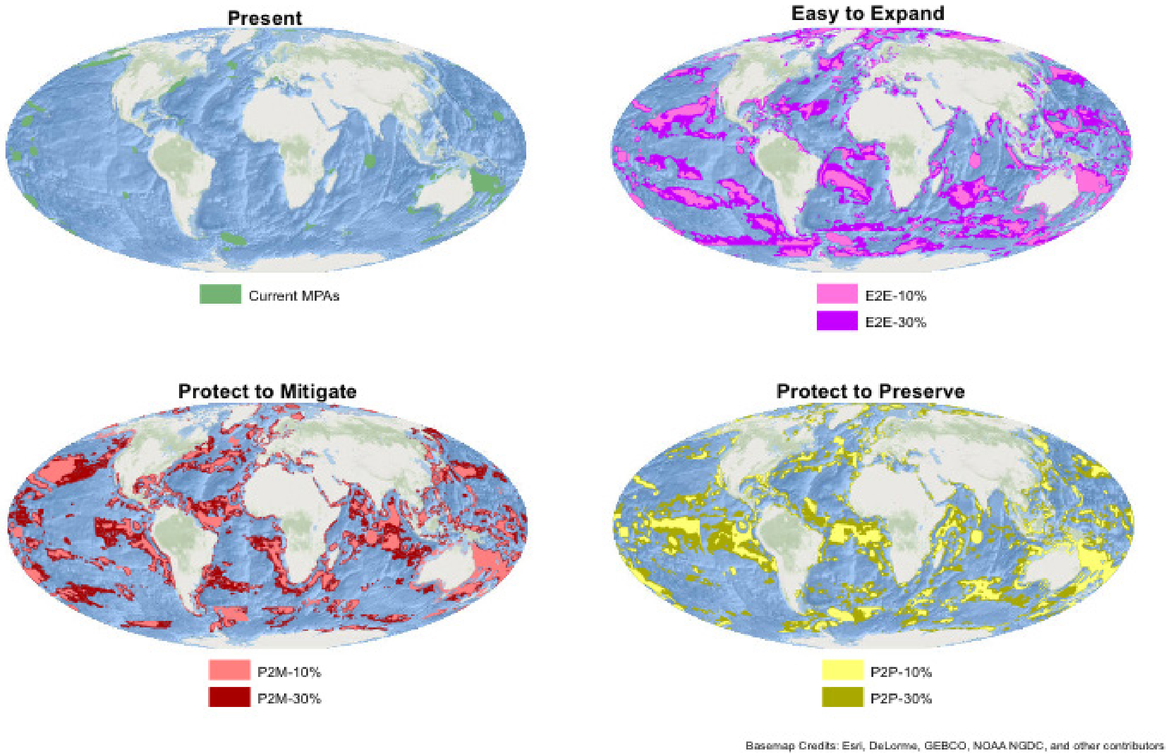


Figure 12. Current and future global distributions of marine protected areas

The methodological framework for the CBA incorporates spatially explicit estimations of bio-physical effects, benefits and costs and is represented by Figure 13.

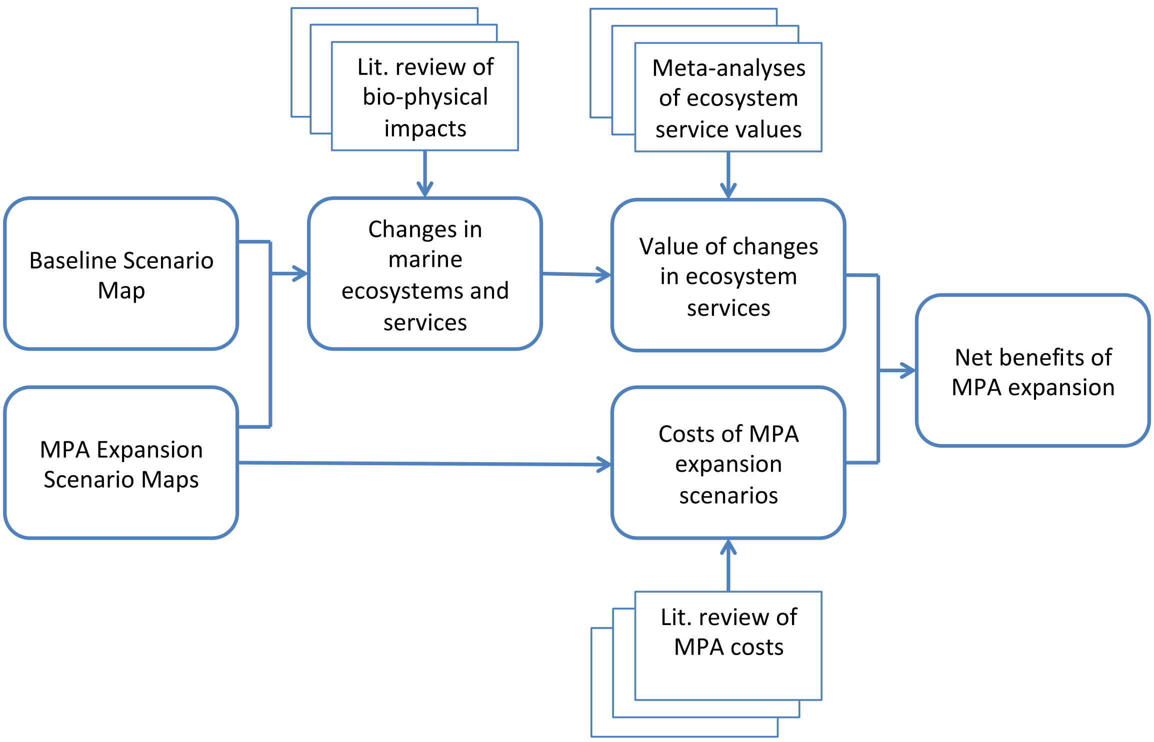


Figure 13: Methodological framework for cost-benefit analysis of expanding marine protected areas. (Adapted from Figure 2, Balmford et al., 2011; and Figure 2, Hussain et al., 2011).

The results of the cost-benefit analysis show that all six scenarios for expanding MPAs to 10% and 30% coverage are economically advisable (see Figure 14). The ratios of benefits to costs are in the range 3.17 – 19.77. In the case of the scenario that achieves 10% coverage of total marine area and targets areas with high biodiversity and low human impact, each dollar invested yields a return of around 20 dollars in benefits.

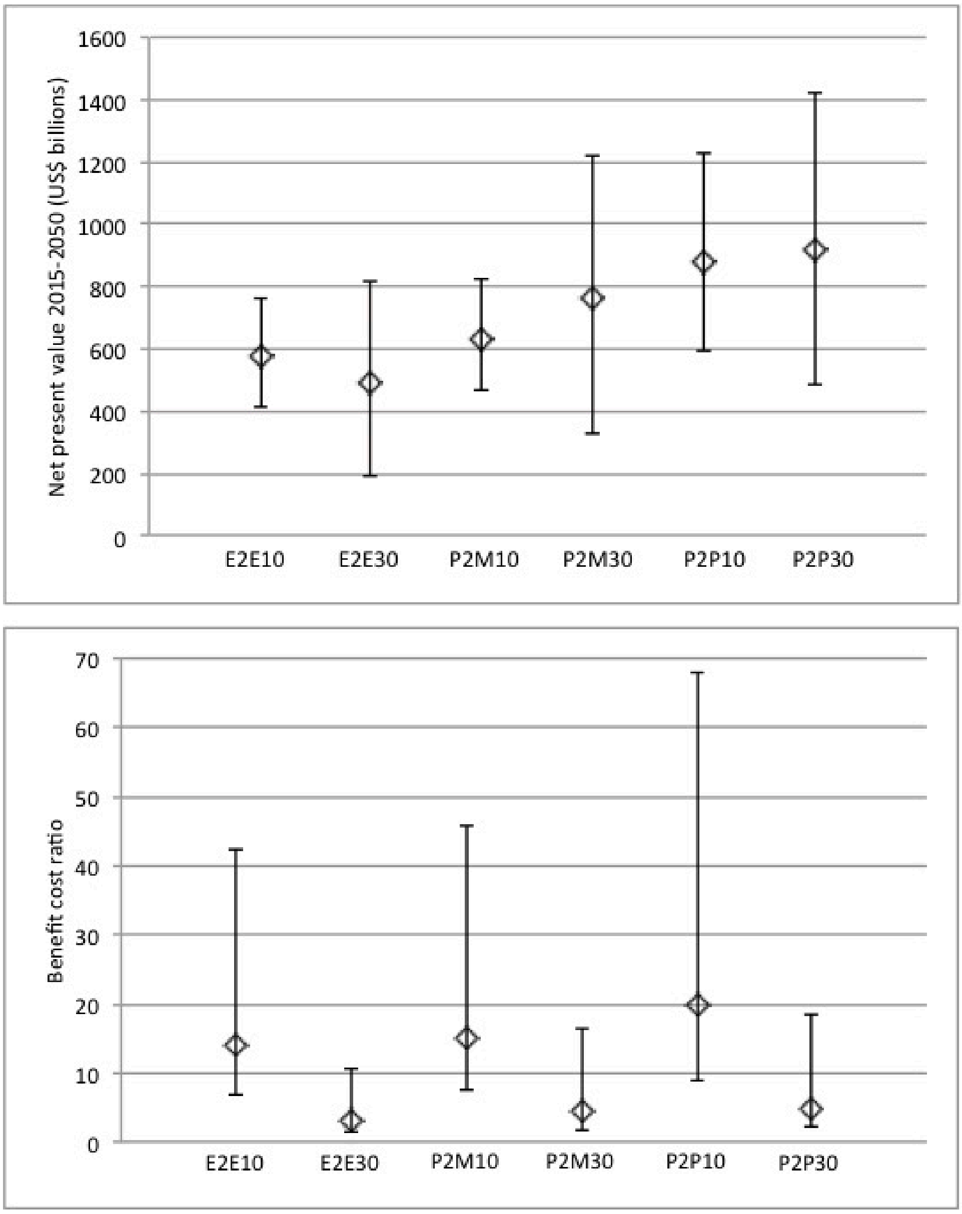


Figure 14. Net present values (US$; billions; 2013 price level; discount rate of 3%) and benefit cost ratios. Error bars represent the combinations of high benefits-low costs (upper bound) and low benefits-high costs (lower bound) drawn from 95% prediction intervals for each cost and benefit.

7.3 Multi-Criteria Analysis (MCA)

Multi-criteria analysis (MCA) has become a well-established tool for decision-making that involves conflicting or multiple objectives. MCA can be used to establish preferences between alternative options by reference to a set of measurable criteria that the decision making body has defined. Unlike in a CBA, criteria do not need to be quantified in a common metric (i.e. money). Instead MCA provides a number of alternative ways of aggregating the data on individual criteria to provide indicators of the overall performance of options. This allows the inclusion in the analysis of effects that cannot be expressed in monetary terms. The basic idea behind MCA is to allow the integration of different objectives (or criteria) without assigning monetary values to all of them. In short, MCA provides a systematic method for comparing these criteria, some of which may be expressed in monetary terms and some of which are expressed in other units. The main steps in performing a MCA are presented in Figure 15.

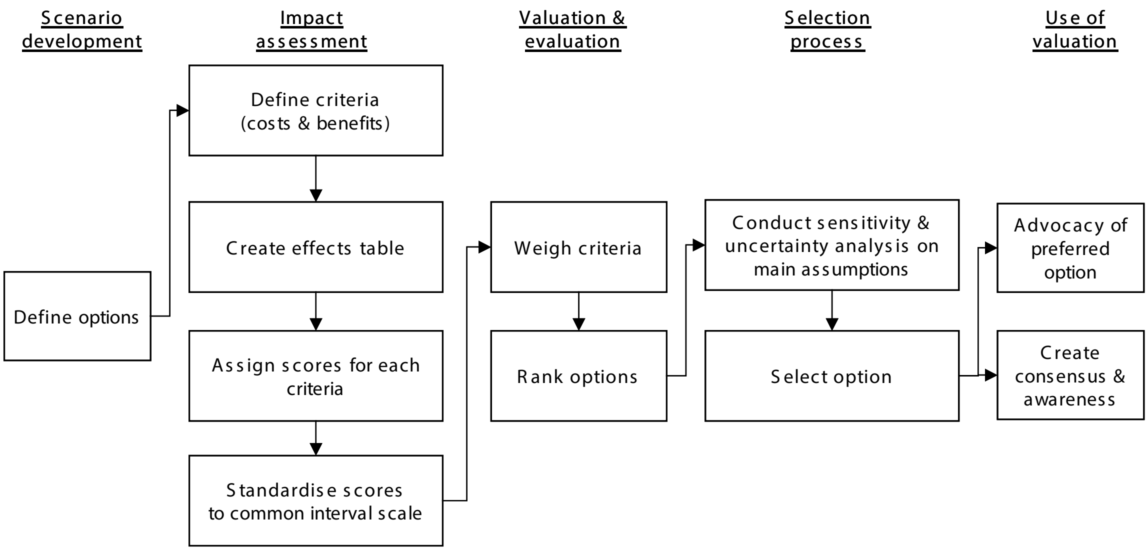


Figure 15: Methodological steps in multi-criteria analysis (Brander and van Beukering, 2015)

Impact assessment in a MCA involves identifying and defining all criteria that are relevant to the decision problem. These include all important categories of negative and positive effects resulting from the options under consideration. In a MCA it is possible to include criteria that are difficult to quantify and can perhaps only be assessed in qualitative terms such as political sensitivity, equity and irreversibility. The quantification of the different effects is summarised in an "effects table", which is a matrix with the alternative options listed in the columns and the criteria listed in the rows. The effects table is completed by assigning scores to each criterion for each alternative. Information on the magnitude of each criterion can be expressed in monetary units, physical units, or simply on a qualitative scale. Data on impacts can be collected from surveys, existing data, experts, or stakeholders. In cases in which the spatial distribution of impacts is important to the decision, the data on impacts can be represented on maps. To enable the direct comparison of different criteria, standardisation of scores for each criterion to a common interval scale is conducted (usually to values between 0-100 or 0-1). There are several software packages available that can be used to help with the computations in MCA.[5]

5 A number of software packages are available to structure and process information in an MCA, including: DEFINITE, HIVIEW, MACBETH, VISA and ILWIS.

MCA does not explicitly value the criteria in monetary terms but instead applies weighting of criteria to quantify the relative importance of each criterion in the decision process. Weights can be derived from existing information or from stakeholders by asking them to state their preferences for the various criteria. By combining the standardised scores and weights of the criteria, the alternative options can be ranked, usually through a weighted summation of criteria scores for each alternative. Similar to CBA, MCA applies sensitivity and uncertainty analysis to assess the robustness of the ranking result to changes in weights and scores. Finally, based on the ranking of options and the sensitivity of the results, a decision maker can select the most preferred option.

A key strength of MCA is that it is not necessary to quantify all impacts in monetary terms. This means that complex and time-consuming valuation studies of all environmental impacts can be avoided, and that qualitative criteria such as political sensitivity can be included in the decision framework. MCA can therefore provide a degree of structure, analysis, and openness to decision problems that lie beyond the practical reach of CBA.

MCA is, however, heavily reliant on the judgement of the analytical team for defining alternatives and criteria, estimating the relative importance of criteria and, to some extent, in calculating and inputting data into the effects table. The subjectivity that pervades these processes can be a matter of concern. The involvement of stakeholders in defining criteria and setting weights can also be time consuming process if conducted using surveys, interviews or deliberative methods. Another important limitation of MCA is that the results do not necessarily show whether alternative options produce welfare gains or losses. Unlike CBA, there is no decision rule (such as a positive NPV, a BCR greater than 1, or an IRR greater than the market interest rate) that indicates that benefits exceed costs. In MCA, as is also the case with CEA, the analysis can only produce a ranking of alternative options and does not indicate whether the options result in a welfare improvement. It is, however, often possible to include a business-as-usual alternative in the set of options, and this can be used as a reference point to indicate whether the other options are better or worse than undertaking no action.

Table 9: Summary of economic appraisal methods

APPRAISAL METHOD	APPLICATION	STRENGTHS	WEAKNESSES
Cost-Effectiveness Analysis (CEA)	Used for identifying lowest cost policy options to achieve a given objective	Does not require assessment of benefits and is analytically relatively straightforward	Limited applicability to ecosystem services given complex and multi-functional nature of ES provision; and the absence of single quantified policy targets
Cost-Benefit Analysis (CBA)	Used to estimate the economic performance of investments and policies	Provides a measure of how much an investment or policy contributes to societal wellbeing	Requires that all costs and benefits are quantified in monetary terms; can result in omission of important effects
Multi-Criteria Analysis (MCA)	Used to rank alternative investments and policies	Allows the inclusion of effects that cannot be expressed in monetary terms	Heavily reliant on the subjective judgment of the analytical team

8. Economics of natural resource management

Natural resource management is an interdisciplinary approach to organising human use of natural resources to optimise their contribution to human welfare. Natural resources are materials and energy sources that occur naturally, such as timber, fish, water, oil, gas and wind. As such, natural resource management encompasses both biotic (natural capital and ecosystem services) and abiotic resources.

Natural resource management draws on knowledge and expertise from physical, biological, economic and other social sciences to make the best use of available natural resources. Natural resource management specifically focuses on the interaction of biophysical and socio-economic systems to understand resource use and enable better stewardship. In particular, it examines the dynamic relationships between resources, use and human welfare.

There is a long history in marine and fisheries economics to view marine and coastal systems as dynamic systems in which biological and human systems interact (Anderson 1977). The biological system dynamics involve both temporal and spatial dimensions. What economics brings in addition is the human system connected to the biological system. For example, when a fisheries sector harvests fish, the fish population declines and its future growth changes. Using ecological principles, one can determine the maximum sustainable yield for a fishery (the maximum total catch per time period that can be taken without long term depletion of the stock); and by using economic principles, one can determine the economic optimal yield (the total catch that maximises net benefits in the fishery).

A useful recent review and comparison of integrated ecological-economic fisheries models (IEEFMs) is provided by Nielsen *et al.* (2017). IEEFMs can be used to evaluate the impacts and sustainability of potential management actions and understand ecological, economic and social dynamics at a range of scales from local to national and regional. The review examines the nature of the advice that can be provided by such models and the impact on decisions taken by managers.

Natural resource management shares several key elements with the ecosystem-based approach (EBA) to managing natural systems. EBA builds on the recognition and understanding of complete ecosystems, including all their interlinked components, processes and relationships, be it of environmental or anthropogenic nature, or transboundary in jurisdiction. The EBA is at the core of LME management and is addressed in other toolkits. See the **›› Strategic Approach Toolkit section 2 on the ecosystem based 5-module approach** and **›› section 5 on ecosystem based management**; the **›› Governance Toolkit section 3.2.1 on the ecosystem approach to fisheries management**; the **›› Marine Spatial Planning toolkit section 5.6 on understanding the ecosystem based approach**; and the Capacity Development Assessment Guide section 3 on ecosystem-based management and its needed capacity.

9. Climate change economics

Climate change caused by the emission of greenhouse gases into the atmosphere from burning fossil fuels and land use change has been described as "the mother of all externalities" (Tol 2009). Climate change economics addresses the measurement of economic impacts of climate change, assessment of costs and benefits of greenhouse gas mitigation, assessment of costs and benefits of adaptation to the impacts of climate change, and the design of economic policy instruments to promote both mitigation and adaptation. Here we introduce the following topics that are directly relevant to LME/MPA/ICM: damage assessment, adaptation planning, ecosystem based adaptation, and blue carbon.

9.1 Climate change damage assessment

Climate change is expected to result in several, predominantly negative, impacts on coastal and marine ecosystems and the communities that use them. Direct impacts to coastal communities include damage to property, infrastructure and loss of life from extreme storm events, flooding due to sea level rise, saline intrusion into groundwater and agricultural land, and loss of marine food resources. Climate change impacts affecting fisheries include changes in food availability, recruitment, and distribution. Climate change impacts to tourism include changes in optimal temperatures, frequency and severity of extreme weather events, damage to infrastructure and facilities, and loss of biodiversity.

Economic assessments of damages resulting from climate change measure the magnitude and distribution of impacts, usually in monetary terms. This information can be useful for identifying the scale of the problem, raising public awareness and motivating responses in terms of both mitigation and adaptation. The scale of the assessment largely determines the method used to make economic damage assessments. Integrated Assessment Models (IAMs), combined macroeconomic and atmospheric models, have been used for global or regional scale assessments. Local scale assessments of climate change damages often couple together models or information that describe each step of the impact pathway from changing climate parameters, biophysical impacts, to economic and social consequences.

9.2 Vulnerability assessment and adaptation planning

Vulnerability is the degree to which a system or community is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the magnitude and rate of climate change to which a system is exposed, its sensitivity to climate change, and its adaptive capacity. A vulnerability assessment therefore involves identifying and quantifying exposure to changing climate conditions, sensitivity to those changes and the capacity to adapt to them. Vulnerability assessments can be used as a first step in planning adaptation measure by: (1) identify areas most likely to be impacted by projected changes in climate;

(2) build an understanding of why these areas are vulnerable, including the interaction between climate change, non-climatic stressors, and cumulative impacts; and (3) identify and target adaptation measures to communities with the greatest vulnerability.

Adaptation involves anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise damage. Autonomous adaptation is undertaken by economic actors in response to observed climate change (e.g. switching target fish species, migration, choosing alternative tourist destinations); whereas planned adaptation is undertaken in anticipation of climate changes (e.g. building seawalls, reducing pressures on coral reefs).

The Micronesia Conservation Trust and the Pacific Islands Managed and Protected Area Community have developed a simple adaptation planning tool targeted at coastal communities called the Vulnerability Assessment Local Early Action Plan (VA-LEAP). The VA-LEAP includes the following 6 steps:

1. Getting organized,
2. Raising community awareness,
3. Assessing non-climate threats,
4. Developing a local climate story,
5. Assessing vulnerability to climate change, and
6. Finalizing your local early action plan for climate change adaptation.

The VA-LEAP is a simple planning tool that practitioners can use to guide actions that can be taken to improve management of important resources while taking climate change impacts into consideration. Developing a VA-LEAP includes identification of prioritization of social and natural resources, identification of threats, characterization of the vulnerability of priority resources to climate change impacts, identification of potential solutions to address threats and to reduce vulnerability to climate change impacts, identification of desired results and measurable objectives, and development of an action plan to achieve those results. The VA-LEAP results can be used by community members and local government and/or NGOs to begin to implement actions that are feasible for natural resource management climate change adaptation at the local level.

The VA-LEAP is a "qualitative" assessment using descriptive information obtained through community discussion, local experience and knowledge. The process is focused on collecting local knowledge and information to understand the perceived status of natural and social resources, and the vulnerability of these resources to climate changes based on existing non-climate threats, past and current experience, and future predictions. The identified adaptation measures can then be subjected to a more quantitative economic appraisal such as cost-benefit analysis or multi-criteria analysis.

Vulnerability Assessment Local Early Action Planning and Management (VA-LEAP) tool

9.3 Ecosystem based Adaptation

Ecosystem-based adaptation (EbA) is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change (Convention on Biological Diversity, 2009). EbA involves a wide range of ecosystem management activities to increase the resilience and reduce the vulnerability of people and the environment to climate change. In the context of marine and coastal management, there is substantial interest in the use of coastal ecosystems (e.g. dunes, mangrove, coral reefs and wetlands) to buffer the impacts of storms and coastal flooding. In addition to regulating services that reduce the impacts of climate change, EbA may also involve enhancing production of ecosystem provisioning and cultural services in the face of climate change threats to these services.

A number of international initiatives have been implemented to identify the conditions under which EbA is effective in order to provide evidence, motivation and guidance to undertake EbA as part of planned adaptation responses to climate change. Such initiatives have examined the benefits, costs and limitations of EbA and promote the integration of EbA into policy and planning.

The project ""Ecosystem-based Adaptation: Strengthening the evidence and informing policy" implemented by IUCN, the International Institute for Environment and Development (IIED), and UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) have produced a set of guidance publication on EbA.

GIZ has developed a sourcebook and training module to assist in building capacity about why, how and in which contexts EbA valuation can be used to inform adaptation decision-making. The sourcebook provides information on valuation methods, practical steps for conducting an EbA valuation study, and 40 case study example applications:

A useful source of information on past and on-going EbA projects is the weADAPT online platform. This is a collaborative platform on climate adaptation issues that enables the sharing of experiences and ideas on EbA and climate change adaptation in general. It allows practitioners, researchers and policy-makers to access credible, high-quality information and connect with one another.

Another useful online resource for sharing experience and knowledge of sustainable management of marine ecosystems, including but not limited to EbA, is the Blue Solutions platform. Blue Solutions provides a global platform to gather, share and generate knowledge on sustainable management and equitable governance of the marine environment. Information on this platform is organised across five themes, one of which is climate change. The other themes are coastal and marine spatial planning and management; protected areas management and governance; ecosystem services; and sustainable financing.

9.4 Blue carbon

Mangroves, salt marshes, seagrasses, and algae (pelagic or benthic) all remove carbon dioxide from the atmosphere and store it in their fibres, in the soil, and/or in the ocean substrate (Pendleton *et al.* 2012; Siikamäki *et al.* 2013). The amount of carbon that is captured from the atmosphere by different plant species can be quantified in terms of a rate of sequestration. If a tree or plant is destroyed or damaged, the carbon stored in the plant's cells is released as the biomass decays or burns. Carbon stored in the soil/substrate may be released over time if left un-vegetated, or released quickly if the substrate is disturbed. Both the rate at which carbon is added to biomass/substrate (sequestration rate) and any release of stored carbon are important and can be used together to calculate the net change in atmospheric carbon dioxide, in a given time period. Data on the rates of carbon sequestration by different ecosystems and the extent of those ecosystems can be used to estimate annual quantities of carbon sequestration; data on the quantity of stored carbon in different ecosystems and reductions in extent of those ecosystems can be used to estimate the annual quantity of carbon prevented from release or decay into the atmosphere (Siikamäki *et al.* 2012).

By convention, quantities of carbon are often expressed in terms of tonnes of CO2-equivalent in order to allow comparison with other greenhouse gases. The conversion rate between carbon and CO2 is 1 tC = 3.67 t CO2. To estimate the economic value of sequestered or avoided release of carbon, the relevant value per tonne of CO2 is the social cost of carbon (SCC), which is the monetary value of damages caused by emitting one more tonne of CO2 in a given year (Pearce 2003). The SCC therefore also represents the value of damages avoided for a small reduction in emissions, in other words, the benefit of a CO2 reduction (US EPA 2016). The SCC is intended to be a comprehensive estimate of climate change damages but due to current limitations in the integrated assessment models and data used to estimate SCC, it does not include all important damages and is likely to under-estimate the full damages from CO2 emissions. The estimated SCC used by the US EPA and other US agencies for appraisal of emissions reductions in 2015 is US$ 56/tonne CO2, using an annual discount rate of 2.5%.

The observed price in a carbon market is an alternative value per tonne CO2 commonly used in the appraisal of emissions reductions. The problem with this approach is that prices in carbon markets are largely artefacts of the set up and regulation of the market and do not reflect the benefits of carbon sequestration. It is therefore advisable to use SCC for assessments of the global value of carbon sequestration by ecosystems. The use of carbon market prices should, however, be used in financial assessments of carbon sequestration projects in order to reflect potential revenues for the project. An indicative estimate of the price of carbon credits on the voluntary market is provided by Forest Trends (2014), which reports an average price in 2013 of US$ 4.90 t CO2-eq. Carbon market prices reflect value to the resource owners; social costs of carbon represent global avoided cost values.

The steps in carbon sequestration quantification and valuation are (Salcone *et al.* 2016):

1. Estimate the quantity of carbon added to the stock of carbon stored in coastal ecosystems during the current year.

   1.1. Obtain data on the current spatial extent of mangroves and seagrass beds.

   1.2. Compute the quantity of carbon sequestered in the current year (i.e. the addition to the stored stock of carbon in that single year). Multiply the area of each ecosystem by estimates of the annual sequestration rate of each ecosystem. Where available, use estimates that reflect local species and conditions. The Blue Carbon Initiative by the Nicholas Institute for Environmental Policy Solutions at Duke University has summarized global coastal carbon data and report an average sequestration rate for mangroves of 6.3 tCO_2/ha/yr (Murray *et al.* 2011).[6]

2. Estimate the (potentially avoided) quantity of carbon released due to reductions in area of coastal ecosystems.

   2.1. Identify current rates of change in areas of coastal ecosystems.

   2.2. Compute the change in area of each ecosystem in the current year (total area of ecosystem multiplied by percentage change) (average for Oceania: 0.39% for loss of mangroves (Sifleet *et al.* 2011); global average is from 0.7% to 2.1% (Murray *et al.* 2011).

   2.3. Compute the quantity of stored carbon released to the atmosphere. Here it is necessary to make an assumption regarding the rate at which stored carbon is released following a change in land use from coastal ecosystem to some other land use, such as agriculture or commercial/industrial development.

      2.3.1. Compute the quantity of carbon stored in living biomass using available estimates. For mangroves, average biomass carbon ranges between 237 t CO_2-eq/ ha - 563 t CO_2-eq/ha (Murray et al., 2011). Regarding the rate at which biomass carbon is released, it can be assumed that if the mangrove is burned, 75% of biomass carbon for mangroves is released immediately and that the remaining 25% decays with a half-life of 15 years (i.e. a further 12.5% is released within 15 years, a further 6.25% is released within 15 years after that, etc.) (Murray *et al.* 2011).

      2.3.2. Compute the total quantity of carbon stored in soil that is released following removal of the ecosystem using available estimates. The average amount of carbon stored in the top meter of soil beneath mangroves is 1060 t CO_2-eq /ha for estuarine mangroves and approximately 1800 t CO_2-eq /ha for oceanic mangroves (Murray *et al.* 2011). Regarding the rate at which this is released, it can be assumed that mangrove soil organic carbon has a half-life of 7.5 years (i.e. 50% of the stored carbon is released in the first 7.5 years, 25% in the following 7.5 years, etc.) (Murray *et al.* 2011).[7]

6 It is advisable to convert all quantities of carbon to tonnes CO2-equivalent (1 tC = 3.67 t CO2-eq) since prices and damage costs of GHG emissions are most often stated in US$/tCO2-eq. Keeping all quantities in CO2-eq reduces the chance of mixing up the units in which carbon is measured.

7 An alternative assumption, also from Murray *et al.* (2011), is that oceanic mangroves release 82 t CO_2e/ha/yr and estuarine mangroves release 59tCo2e/ha/yr for 25 years following clearance of the mangrove trees.

3. Value the flow of carbon

3.1. For additions to the stocks of carbon stored in each ecosystem, multiply the annual quantity of sequestered carbon in step 1.2 (tonnes CO_2-eq) by the social cost of carbon.

3.2. For the market value of (potentially avoided) carbon release, the "benefit" is the sale of carbon credits that represent avoided emissions. In this case, multiply the total quantity of (potentially avoided) carbon emissions (tonnes CO_2-eq) estimated in step 2.31 and 2.32 by the market price.[8] If relevant cost data is available, subtract the costs of managing and crediting emissions reductions to estimate producer surplus.

A useful resource is the Blue Carbon Initiative, a global program working to mitigate climate change through the restoration and sustainable use of coastal and marine ecosystems. The Blue Carbon Initiative has produced a manual on assessing carbon stored in coastal ecosystems: "Coastal Blue Carbon: methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrass meadows" (Howard et al.,2014).

8 This calculation is made with the assumption that avoided emissions that will occur in the future (i.e. as biomass and soil carbon is released over time) can be credited and sold in the current year. If this is not the case, it would be necessary to estimate the quantity of carbon released in each year following the land use change and then compute a present value of the stream of credits.

10. Blue economy

The term "blue economy" refers to the use of the marine environment and its resources for sustainable economic development. The concept of the blue economy clearly covers a broad range of economic sectors (fisheries, renewable and non-renewable energy, tourism, aquaculture, transportation, bioprospecting, mineral extraction, and nature conservation) and related environmental issues (pollution, climate change, ocean acidification, over-harvesting and habitat loss). There is also explicit recognition of the role of the marine environment in delivering multiple ecosystem services, both marketed and non-marketed. The challenge of the blue economy concept is to understand the economic importance of these multiple uses, how they interact, and how to manage the overall use of the marine environment over the long term. It is recognised that addressing this challenge requires collaboration across stakeholders, jurisdictions and scales. The blue economy concept seeks to promote economic growth, social inclusion, and the preservation or improvement of livelihoods while at the same time ensuring environmental sustainability of the oceans and coastal areas. It is directly relevant to and compatible with the concept of LME management.

Measuring the importance of the blue economy draws on several of the tools outlined in this toolkit, specifically on economic impact assessment (chapter 3.2), valuation methods (chapter 4), natural capital accounting (chapter 5), and blue carbon (chapter 9.4). The Example Box on the state of oceans and coasts in the East Asian Seas describes preliminary results on the importance of the blue economy in this region.

→ WWF report on principles for a sustainable blue economy.

→ World Bank report on the potential of the blue economy.

Example Box 11: State of Oceans and Coasts in the East Asian Seas Region

This case presents preliminary results of a regional State of Oceans and Coasts (SOC) report for East Asian Seas prepared by Partnerships in Environmental Management for the Seas of East Asia (PEMSEA). The purpose of the SOC is to measure progress and outcomes of the implementation of the SDS-SEA, UN SDGs, and other related international commitments.

The regional SOC report integrates information from national SOC reports and sub-regional and LME reports; synthesize the common issues, shared resources and values from the East Asian Seas; and present solution options and recommendations to ensure the flow of ecosystem services, improve ocean health, and promote the blue economy. In this context, the blue economy was defined in the Changwon Declaration

2012 and focuses on the economic perspective of the ocean economy and the natural oceanic capital while meeting the goals of healthy oceans and a more sustainable development. It involves a paradigm shift towards a sustainable, innovative, and inclusive ocean economy that ensures economic growth, welfare, ocean health and resilience.

The SOC report has a blue economy theme to highlight: (a) the contributions of oceans and coasts to national economies, income, livelihood and welfare; (b) state of ocean health, which could affect the ocean economy and ecosystem services; (c) the EAS region's transition from the traditional ocean economy to blue economy, and investment opportunities; (d) innovative policies and governance mechanisms supporting blue economy development.

The entire ocean economy is measured as the sum of the economic activities of ocean-based and ocean-related industries, together with the natural assets, goods and services of marine ecosystems upon which these industries depend on, and people rely on for food, income, livelihood, recreation, shoreline protection, climate regulation, etc. The ocean economy as reported by eight countries in their draft SOC reports was estimated to be worth around $1.42 trillion in value added. Around 50 million people (in five countries) are employed in the ocean industries. For seven countries, the total estimated value of coastal and marine ecosystems is around $531 billion. The potential blue carbon value in the region was estimated to be $111 billion for mangroves, and $77-95 billion for seagrass.

Table 10. Summary of the size of the blue economy in East Asia

COUNTRY	OCEAN ECONOMY		**VALUE OF ECOSYSTEM SERVICES** (US$; BILLIONS)
	US$; BILLIONS	SHARE OF GDP (%)	
CAMBODIA			0.08
CHINA	959	9.5	
INDONESIA	183	28	412
MALAYSIA	63	23	18
PHILIPPINES	12	7.0	17
RO KOREA	44	3.3	42
THAILAND	118	30	36
TIMOR LESTE	2	87	5
VIET NAM	38	21	

11. Conclusion

The environmental economics methods introduced in this toolkit can be applied to inform the use and management of marine ecosystems in a wide array of policy contexts, including: advocacy and raising public awareness; appraisal of projects, investments and policies; impact assessment; sustainable financing; and setting compensation for environmental damage. Such information can be useful input to specific management processes addressed by the GEF LME:LEARN project, including LME financing, TDA, MPA appraisal, marine spatial planning and the design of ecosystem based adaptation investments.

The purpose of applying environmental economic methods is ultimately to provide relevant, credible and actionable information to support better use and management of marine resources. This primary aim should be kept firmly in mind when applying methods and presenting results; and any application should be designed to provide information that is directly useful and understandable to the decision makers involved. Adhering to the following conditions/ principles can help ensure that the information produced by an environmental economics analysis achieves this aim: access to and partnership with the decision-makers using the information; identify clear policy questions or information demands to be addressed; high transparency regarding the methods, data and analysis to ensure trust and credibility. Environmental economics analysis is not an end in itself, but a means to better informed decision-making that results in sustainable use of marine ecosystems.

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Glossary of economic terms

Avoided (damage) cost valuation method	A cost-based valuation technique that estimates the value of the role an ecosystem plays in regulating natural hazards (e.g. floods and landslides) by calculating the damage that is avoided due to the ecosystem service.
Choice modelling	Choice modelling attempts to model the decision process of an individual in a particular context. Choice modelling may be used to estimate non-market environmental benefits and costs. It involves asking individuals to make hypothetical trade-offs between different ecosystem services.
Consumer surplus	The difference between what consumers are willing to pay for a good and its price. Consumer surplus is a measure of the bene t that consumers derive from the consumption of a good or service over and above the price they have paid for it.
Contingent valuation	Contingent valuation is a survey-based economic technique for the valuation of non-market resources, such as environmental preservation or the impact of contamination. It involves determining the value of an ecosystem service by asking what individuals would be willing to pay for its presence or maintenance.
Cost-Benefit Analysis	An evaluation method that assesses the economic efficiency of policies, projects or investments by comparing their costs and benefits in present value terms. This type of analysis may include both market and non- market values and accounts for opportunity costs.
Demand	The amount of a good or service consumed or used at a given price; consumers will demand a good or service if the bene t is at least as high as the price they pay.
Direct use value	The value derived from direct use of an ecosystem, including provisioning and recreational ecosystem services. Use can be consumptive (e.g. fish for food) or non-consumptive (e.g. viewing reef fish).
Discount rate	The rate used to determine the present value of a stream of future costs and benefits. The discount rate reflects individuals' or society's time preference and/or the productive use of capital.
Discounting	The process of calculating the present value of a stream of future values (benefits or costs). Discounting reflects individuals' or society's time preference and/or the productive use of capital. The formula for discounting or calculating present value is:
Economic activity	The production and consumption of goods and services. Economic activity is conventionally measured in monetary terms as the amount of money spent or earned and may include 'multiplier effects' of input costs and wages

Economic benefit	the net increase in social welfare. Economic benefits include both market and non-market values, producer and consumer benefits. Economic bene t refers to a positive change in human wellbeing.
Economic contribution	The gross change in economic activity associated with an industry, event, or policy in an existing regional economy.
Economic cost	A negative change in human wellbeing.
Economic impact	The net changes in new economic activity associated with an industry, event, or policy in an existing regional economy. It may be positive or negative.
Economic value	(i) The monetary measure of the wellbeing associated with the production and consumption of goods and services, including ecosystem services. Economic value is comprised of producer and consumer surplus and is usually described in monetary terms. or (ii) The contribution of an action or object to human wellbeing (social welfare).
Ecosystem functions	The biological, geochemical and physical processes and components that take place or occur within an ecosystem.
Ecosystem service approach	A framework for analysing how human welfare is affected by the condition of the natural environment.
Ecosystem service valuation	Calculation, scientific and mathematic, of the net human benefits of an ecosystem service, usually in monetary units.
Ecosystem services	The benefits that ecosystems provide to people. This includes services (e.g. coastal protection) and goods (e.g. fish).
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.
Evaluate	To assess the overall effect of a policy or investment.
Evaluation	The assessment of the overall impact of a policy or investment. Evaluations can be conducted before or after implementation of a policy or investment.
Existence value	The value that people attach to the continued existence of an ecosystem good or service, unrelated to any current or potential future use.
Factor cost	Total cost of all factors of production consumed or used in producing a good or service.
Financial benefit	A receipt of money to a government, firm, household or individual.
Financial cost	A debit of money from a government firm, household or individual.

Future value	A value that occurs in future time periods. See also present value.
Green accounting	The inclusion of information on environmental goods and services and/or natural capital in national, sectoral or business accounts.
Gross revenue	Money income that a firm receives from the sale of goods or services without deduction of the costs of producing those goods or services. Gross revenue from the sale of a good or service is computed as the price of the good (or service) multiplied by the quantity sold.
Gross value	The total amount made as a result of an activity.
Hedonic pricing method	A method for pricing ecosystem services. Hedonic price models assume that the price of a product reflects embodied characteristics valued by some implicit or shadow price.
Indirect use value	The value of ecosystems services that contribute to human welfare without direct contact with the elements of the ecosystem, for example regulating services such as plants producing oxygen or coral reefs providing coastal protection.
Instrumental value	The importance of something as a means to providing something else that is of value. For example, a coral reef may have instrumental value in reducing risk to human life from extreme storm events.
Intermediate costs	The costs of inputs or intermediate goods that are used in the production of final consumption goods. For example, the cost of fishing gear used to catch fish is an intermediate cost to the harvest and sale of fish.
Intrinsic value	The value of something in and for itself, irrespective of its utility to something or someone else. Not related to human interests and therefore cannot be measured with economic methods.
Marginal value	The incremental change in value of an ecosystem service resulting from an incremental change (one additional unit) in the quantity produced or consumed.
Market value	The amount for which a good or service can be sold in a given market.
Negative externality	*Negative externalities* occur when the consumption or production of a good causes a harmful effect to a third party.
Net revenue	Monetary income (revenue) that a firm receives from the sale of goods and services with deduction of the costs of producing those goods and services. Net revenue from the sale of a good is computed as the price of the good multiplied by the quantity sold, minus the cost of production.
Net value	The value remaining after all deductions have been made.

Nominal	The term 'nominal' indicates that a reported value includes the effect of inflation. Prices, values, revenues etc. reported in 'nominal' terms cannot be compared directly across different time periods. See also real and constant prices.
Non-use value	The value that people gain from an ecosystem that is not based on the direct or indirect use of the resource. Non-use values may include existence values, bequest values and altruistic values.
Opportunity cost	The value to the economy of a good, service or resource in its next best alternative use.
Option value	The premium placed on maintaining environmental or natural resources for possible future uses, over and above the direct or indirect value of these uses.
Present value	A value that occurs in the present time period. Present values for costs and benefits that occur in the future can be computed through the process of discounting (see discount rate). Expressing all values (present and future) in present value terms allows them to be directly compared by accounting for society's time preferences.
Producer surplus	The amount that producers bene t by selling at a market price that is higher than the minimum price that they would be willing to sell for. Producer surplus is computed as the difference between the cost of production and the market price. Value-added, pro t, and producer surplus are similar measures of the net bene t to producers. Although they differ slightly, the terms are used synonymously for this report to represent economic value.
Profit	The difference between the revenue received by a firm and the costs incurred in the production of goods and services. Value-added, profit and producer surplus are similar measures of the net bene t to producers. Although they differ slightly, the terms are used synonymously for this report to represent economic value.
Purchasing power parity adjusted exchange rate	An exchange rate that equalises the purchasing power of two currencies in their home countries for a given basket of goods.
Purchasing power parity	An indicator of price level differences across countries. Figures represented in purchasing power parity represent the relative purchasing power of money in the given country, accounting for variance in the price of goods. Typically presented relative to the purchasing power of US dollars in the United States.
Real	The term 'real' indicates that a reported value excludes or controls for the effect of inflation (synonymous with constant prices). Reporting prices, values, revenues etc. in 'real' terms allows them to be compared directly across different time periods. See also nominal and constant prices.

Regulating services	A category of ecosystem services that refers to the benefits obtained from the regulation of ecosystem processes. Examples include water ow regulation, carbon sequestration and nutrient cycling.
Rent	Any payment for a factor of production in excess of the amount needed to bring that factor into production (see also producer surplus and resource rent).
Replacement cost method	A valuation technique that estimates the value of an ecosystem service by calculating the cost of human-constructed infrastructure that would provide same or similar service to the natural ecosystem. Common examples are sea walls and wastewater treatment plants that provide similar services to reefs, mangroves, and wetland ecosystems.
Resource rent	The difference between the total revenue generated from the extraction of a natural resource and all costs incurred during the extraction process (see also producer surplus). Refers to pro t obtained by individuals or firms because they have unique access to a natural resource.
Revenue	Money income that a firm receives from the sale of goods and services (often used synonymously with gross revenue).
Social cost of carbon (SCC)	The social cost of carbon is an estimate of the economic damages associated with a small increase in carbon dioxide (CO_2) emissions, conventionally one tonne, in a given year. This dollar figure also represents the value of damages avoided for a small emission reduction (i.e. the benefit of a CO_2 reduction).
Stated preference method	A survey method for valuation of non-market resources in which respondents are asked how much they would be willing to pay (or willing to accept) to maintain the existence of (or be compensated for the loss of) an environmental feature such as biodiversity.
Supply	The quantity of a good or service that producers will supply at a given price; producers will supply goods and services if they at least cover their costs.
Supporting services	A category of ecosystem services that are necessary for the production of all other ecosystem services. Examples include nutrient cycling, soil formation and primary production (photosynthesis).
Total economic value	All marketed and non-marketed benefits (ecosystem services) derived from any ecosystem, including direct, indirect, option and non-use values.
Use value	Economic value derived from the human use of an ecosystem. It is the sum of direct use, indirect use and option values.

User cost	The cost incurred over a period of time by the owner of a xed asset as a consequence of using it to provide a ow of capital or consumption services; the implications of current consumption decisions on future opportunity. User cost is the depreciation on the asset resulting from its use.
Utilitarian value/ Utility	A measure of human welfare or satisfaction. Synonymous with economic value.
Valuation	The process or practice of estimating human benefits of ecosystem services or costs of damages to ecosystem services, represented in monetary units.
Value	The contribution of an action or object to human wellbeing (social welfare).
Value-added	The difference between cost of inputs and the price of the produced good or service. Value-added can be computed for intermediate and final goods and services. Value-added, profit, and producer surplus are similar measures of the net benefit to producers. Although they differ slightly, the terms are used synonymously for this report to represent economic value.
Welfare	An individual's satisfaction of their wants and needs. The human satisfaction or utility generated from a good or service.
Willingness-to-accept	The minimum amount of money an individual requires as compensation in order to forego a good or service.
Willingness-to-pay	The maximum amount of money an individual would pay in order to obtain a good, service, or avoid a change in condition.

GEF LME:LEARN

GEF LME:LEARN is a program to improve global ecosystem-based governance of Large Marine Ecosystems and their coasts by generating knowledge, building capacity, harnessing public and private partners and supporting south-to-south learning and north-to-south learning. A key element of this improved governance is main-streaming cooperation between LME, MPA, and ICM projects in overlapping areas, both for GEF projects and for non-GEF projects. This Full-scale project plans to achieve a multiplier effect using demonstrations of learning tools and toolboxes, to aid practitioners and other key stakeholders, in conducting and learning from GEF projects.

PROJECT COMPONENTS

1. Global and regional network of partners to enhance ecosystem-based management and to provide support for the GEF LME/ICM/MPA projects to address their needs and incorporate climate variability and change considerations.
2. Synthesis and incorporation of knowledge into policymaking; capture of best LME governance practices; and development of new methods and tools to enhance the management effectiveness of LMEs and to incorporate ICM, MPAs and climate variability and change, including the five LME Approach modules.
3. Capacity and partnership building through twinning and learning exchanges, workshops, and training among LMEs and similar initiatives.
4. Communication, dissemination and outreach of GEF LME/ICM/MPA project achievements and lessons learned.

PARTNERS

GLOBAL ENVIRONMENT FACILITY (GEF)

Through its strategic investments, the GEF works with partners to tackle the planet's biggest environmental issues. The GEF is the funding agency for GEF LME:LEARN and the portfolio of projects we provide services to.

UNITED NATIONS DEVELOPMENT PROGRAM

UNDP works to eradicate poverty and reduce inequalities through the sustainable development of nations. UNDP works in cooperation with other UN agencies, the GEF, international financial institutions, regional organizations, NGOs, the private sector and others to improve water and ocean management and sustain livelihoods at local, national, regional and global scales through effective water and ocean governance. UNDP is the implementing agency for the GEF LME:LEARN project. .

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION OF THE UNITED NATIONS EDUCATIONAL SCIENTIFIC AND CULTURAL ORGANIZATION

IOC-UNESCO promotes international cooperation and coordinates programmes in marine research, services, observation systems, hazard mitigation, and capacity development in order to understand and effectively manage the resources of the ocean and coastal areas. IOC-UNESCO is the project executor and contributes capacity building, technical knowledge, data and information exchange, project management, and project sustainability.

INTERNATIONAL UNION FOR CONSERVATION OF NATURE

IUCN provides public, private and non-governmental organizations with the knowledge and tools that enable human progress, economic development and nature conservation to take place together. IUCN is responsible for development of the Environmental Economics toolkit and the LME Hub on the GEF LME:LEARN website.

INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA

ICES is a global organization that develops science and advice to support the sustainable us of the oceans. ICES is responsible for the Governance Working group, delivery of the Governance Toolkit, organization of training courses and dissemination of best practices.

CONSERVATION INTERNATIONAL

CI is a nonprofit environmental organization with a goal to protect nature as a source of food, fresh water, livelihoods and a stable climate. CI is responsible for the development of the toolkits on Stakeholder Participation and LME Assessment, as well as developing a guide on planning and implementing comprehensive marine management capacity development.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (U.S)

NOAA is an agency of the U.S. Department of Commerce that enriches life through science. NOAA has a diverse range of diverse skills and expertise that it shares as part of their continued science and technical support of LME projects and other related capacity building activities for ecosystem-based approaches in the management of coastal and marine resources.

This global project is funded by the Global Environmental Facility (GEF), implemented by the United Nations Development Programme (UNDP), and executed by the Intergovernmental Oceanographic Commission (IOC) of UNESCO. The GEF LME:LEARN's Project Coordination Unit (PCU) is headquartered at UNESCO-IOC's offices in Paris.

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