# Chapter 2
# Conceptual Framework

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## 2.1 Conceptual Framework

Coastal zones and their supporting ecosystems present policy makers with a number of challenges including the need to be flexible in the face of dynamic environmental changes, and a high degree of uncertainty about the consequences for ecosystems and socio-economic systems stimulated by pressures and drivers such as, for example, climate change. In this volume the UK NEA ecosystem services framework (ESF) and related decision support tools (see Fig. 2.1) are used as the basis for adaptive coastal management. This strategy is in line with the broadly based ecosystem approach and is now under test or are being implemented across environmental policy circles (e.g., Saunders et al. 2010 for the Crown Estate, Fletcher et al. 2012 for Natural England).

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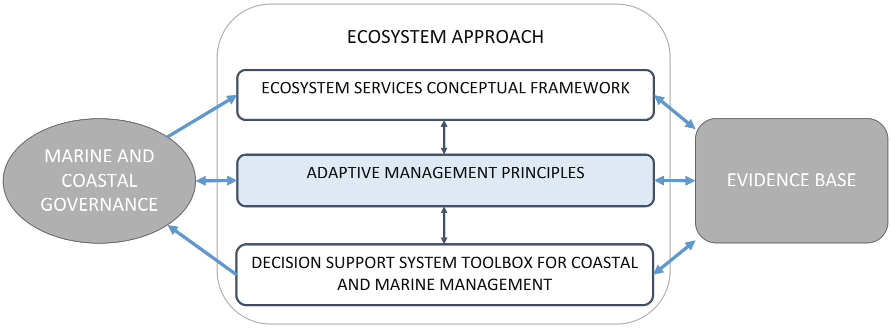


**Fig. 2.1** Implementation of the ecosystem approach (Adapted from the UK NEAFO synthesis report (2014))

A number of flexible 'ground rules' may prove useful in order to guide the application of this ESF and related decision support system (DSS), as well as the interpretation and use of its results by the policy community and society at large. The over-arching adaptive management (AM) approach taken here is built on the foundation principles of pragmatism, decision making anchored to the precautionary principle and pluralism. A pragmatic stance is taken in order to bring the ecosystem services concept more fully into the collective consciousness of government (particularly finance ministries) and business. The methodology therefore deliberately allows for the monetary valuation of the outcomes from 'final' ecosystem services. This stance was pushed further, given the precautionary principle, in the sense that it was judged that sufficient scientific and socio-economic information exists to justify starting to explicitly manage our ecosystems more sustainably and that there is a net benefit from such action. At the same time due recognition needs to be given to the danger of threshold effects because of the scientific uncertainty which shrouds how certain ecosystems may be adversely affected by human development pressures causing them to unexpectedly collapse or lose significant productivity potential.

It will therefore be argued that the ESF also necessitates a plural, interdisciplinary perspective and will require decision makers to operate under conditions of uncertainty, where in some contexts 'full' information will not be available but urgent, or at least short run, precautionary action is necessary. Application of this strategy to dynamic coastal environments and their management will involve just such uncertain and often highly contested ('wicked') policy contexts. Coastal process and ecosystem changes can therefore only be better understood and adaptively managed on the basis of an interdisciplinary 'knowledge' and 'methods and tools' (DSS) capacity.

The coastal management framework set out below is hierarchically arranged. It begins with an explanation of the adaptive management strategy and its high level principles. These were used as guidelines for the deployment of the UK NEA (2011) and UK NEAFO (2014) ESF which in turn provides the focus for a practical DSS, the components of which form the basis for economic and social appraisal and trade-off analysis.

The rest of this chapter is organised into the following sub-sections:

- a characterisation of the strategic-level adaptive management approach encompassing the NEA ESF and the links to relevant decision support tools and methods necessary for more integrated coastal management;
- a classification of coastal and marine ecosystem services, the stock and flow position and the distinction between intermediate and final services;
- the links between processes, ecosystem services and the goods and benefits they provide to human society with wellbeing consequences; and
- an outline of the necessary DSS and its components for practical coastal management.

## 2.2 Policy Context

The interdisciplinary conceptual framework guided by adaptive management (AM) principles and incorporating the ESF and a DSS, seeks to contribute to a more sustainable management of our coastal zones, while *inter alia* at least maintaining the provision of a set of ecosystem services over time. It will also contribute to the UK and other European countries' adoption of the EU Marine Strategy Framework Directive (MSFD) and will draw lessons from the implementation of the EU Water Framework Directive (WFD) and other related Directives and policies, such as the Common Fisheries Policy (CFP). In the UK, for example, the regional marine planning agenda is now the focus of much policy attention driven by legislation such as the UK Marine and Coastal Access Act (2009) and Marine (Scotland) Act 2010, guided by the Marine Policy Statement (MPS) and operationalised by Marine Plans, which set out how the MPS will be implemented in specific areas. The conceptual approach will build on that formulated by the UK National Ecosystem Assessment (UK NEA 2011; Balmford et al. 2011; Bateman et al. 2011) (see Fig. 2.2), and is applied to the coastal zone context. The UK NEA 2011 focused on the processes that link human society and wellbeing to the natural environment and *inter alia* on the key role ecosystems play in delivering a diverse set of services which directly and indirectly underpin economic progress and human wellbeing. The NEAFO (2014) further developed the approach and gave governance and institutions a more central role.

The strategic goal is to build a robust evidence-based case for the embedding of the ESF into the policy process and the workings of the wider contemporary society. However, to foster such a policy switch in practice, new and existing policy tools will need to be combined in a DSS, see Fig. 2.3.

The achievement of the strategic goals of AM will contribute to a better assessment of the value and significance of the flow of ecosystem services over time, as

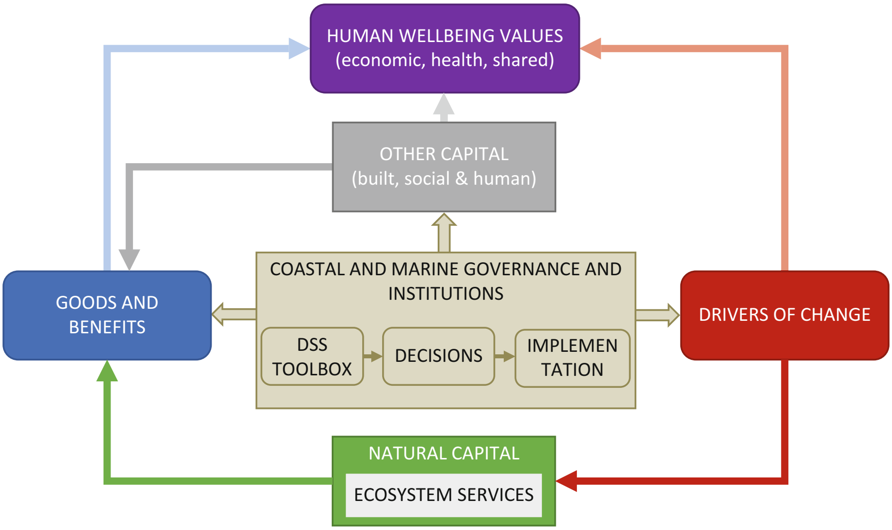


**Fig. 2.2** Ecosystem services conceptual framework (Adapted from UK NEA (2011) and UKNEAFO (2014))

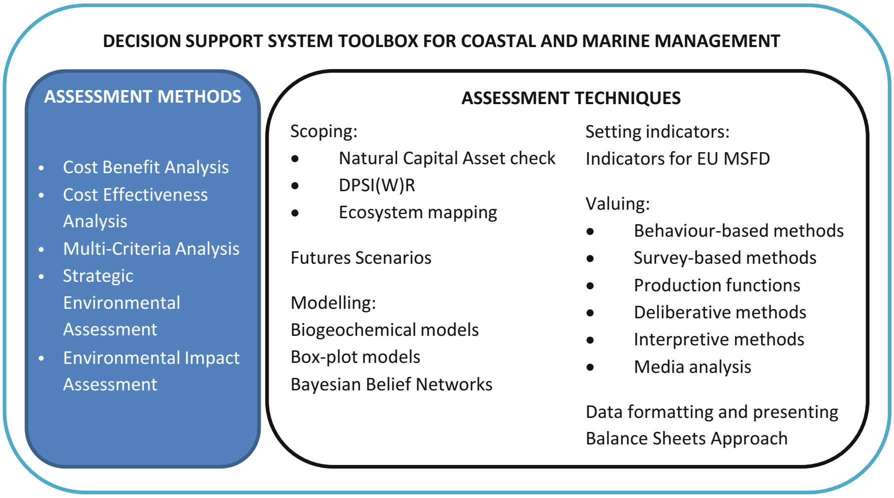


**Fig. 2.3** The DSS toolbox for coastal and marine management with examples of assessment methods and techniques (Adapted from UK NEAFO (2014))

well as an indication of the stock accounting price or value position (natural asset check) at any given point in time. Economic progress cannot be sustainably achieved without good environmental husbandry principles and practice. Sustainability principles can be used to guide the ES framework and approach. This combined approach can then contribute to a fuller quantification and recognition of the true 'comprehensive wealth' of a country (Gross domestic product (GDP) plus) and how it is changing over time (see UNU-IHDP & UNEP 2012). It is also targeted at policy objectives, such as the possible future adoption of a 'strong' sustainable development path (Turner 1993; Turner et al. 2003).

The ESF evolved from an earlier natural science-based analytical approach known as the '**Ecosystem Approach**' as detailed by the 1992 Convention on Biological Diversity (CBD). This advocated a much more comprehensive and integrated approach to environmental management. The next step was to augment the systems-based science by the inclusion of social science and humanities thinking, to link ecosystem functioning and its outcomes to the provision of services (e.g. flood protection, recreation, cultural services and many others) which contribute to human wellbeing. Hence the underlying aim is not so much to solely maximise environmental or biodiversity conservation, but rather to manage the rate of change in ecosystems (structure (including species composition) and functioning (as rate processes)) as socio-economic and ecological systems co-evolve through time.

## 2.3 Adaptive Coastal Management: Principles

Coastal zones are institutional domains with administrative boundaries that can cross regional and national jurisdictions and which are not coincident with the scales and susceptibility of biogeochemical and physical processes (known as the scale mismatch problem). The governance regimes operating across coastal zones therefore face particular challenges. However, political, institutional and coastal management agencies and practices (governance) have so far moved only slowly to encapsulate some core conceptual advances provided by coastal zone 'science' (Mee 2012). These are:

- a recognition that humans are an integral component of the ecology and functioning of ecosystems, and that a process of co-evolution between human society and economy and the environment has now become self-evident due to the scale and intensity of global development and trade;
- environmental management interventions need to be multifunctional rather than focused on single ecosystems or services, with the longer term aim of understanding and managing 'landscape' level ecological processes and relevant socio-economic driving forces and pressures which reduce resilience; therefore the connectivity of a river basin catchment and its receiving coastal waters through to the shelf break is an appropriate functional unit for coastal resource assessment and management;
- to quantify gains and losses from any given policy option choice, it is necessary to assign monetary values to some ecosystem services once translated to societal benefits and to provide non-monetary evaluation of other (particularly cultural) services benefits;

- that new DSSs need to be flexible, allowing refinement and adaptation to changing coastal zone circumstances (such as for example the new focus on marine spatial planning) and governance regimes;
- that some global change impacts (in the absence of radical institutional change at the international governance level) such as temperature change, relative sea-level rise and ocean acidification require a pragmatic adaptive response in advance of long term mitigation and/or compensation;
- because adaptation often results in winners and losers, there is an increasing need for novel forms of compensation in cases where mitigation of adverse effects is insufficient and where the compensation can be for the habitat (e.g. create new habitat), for a resource (such as restocking of affected fish and shellfish stocks) and for users (financial compensation) (Elliott et al. 2007); and
- that the role of the citizen and individual, now often organised via social networks and media, needs to be combined with central decision making in protecting coastal systems quality while at the same time seeking to ameliorate contested values conflict (Potts et al. 2011).

These are all formidable challenges and better DSSs are required if they are to be successfully overcome and progress is made towards more adaptive coastal management. The environmental change forces (often global) that dominate the zone pose risks that are sometimes exacerbated by overly narrow and short term planning and intervention measures, implemented without due regard for ecosystem processes. This temporal mismatch problem is highlighted by situations in which the slow response time of natural systems is challenging for political processes where there are expectations of rapid outcomes from policy interventions. The slow response time also has profound implications for coastal management options and strategies, forcing policymakers to think about taking actions now with consequences that stretch out far into the future. Warming of the deep-ocean and sea-level rise related to increased greenhouse gas (GHG) emissions, for example, are very slow processes taking up to 1,000 years: about a third of the carbon dioxide emitted today will still be in the atmosphere after 1,000 years (Stouffer 2012). We revisit this timescale problem in the context of policy appraisal and the economic discounting procedure in Chap. 4.

In light of the characteristics of coastal zones and policy contexts the adoption of an AM approach at a strategic level is recommended because of, among other things, its emphasis on flexibility and 'learning by doing' practice. Management agencies should therefore be precautionary, giving high priority to coastal functional diversity and related ecosystem services, as well as the maintenance of the system's resistance and resilience (see Box 2.1), i.e. its respective ability to cope with and recover from stress and shock (Turner 2000; Elliott et al. 2007; Elliott 2011). This is a 'stock' quality ('ecosystem health') issue and one that is currently under-researched. We do not know enough about 'minimum' levels of stock structure, processing and functioning and the type and levels of stress that systems can cope with without regime change. This will in turn require the adoption of a relatively broad scale perspective, in order to understand and potentially manage 'landscape' level ecological processes and relevant socio-economic driving forces more cost effectively (de Jonge et al. 2012). A systems-based approach is required to help cope with the inevitable uncertainty that afflicts coastal management and is the basis for AM (Mee 2005).

**Box 2.1. Ecosystem Adaptation**

Ecosystem *adaption* to pressure is a complex process. It can occur at the population and species level as well as within trophic networks. Mechanisms are rarely well known in the case of marine ecosystems, and discussion is often conducted in terms of an emergent property, that of system *resilience*. This refers to the extent that the system maintains its integrity as external pressures increase (*resistance*), or regains that integrity when pressures relax (*recovery*). In Fig. 2.4 the provision of services is shown as a function of ecosystem *state* (indicating integrity or health: see Tett et al. 2013). Recovery, however, may involve change in ecosystem condition (sometimes called regime shift), so that restored services are not identical with those before system collapse.

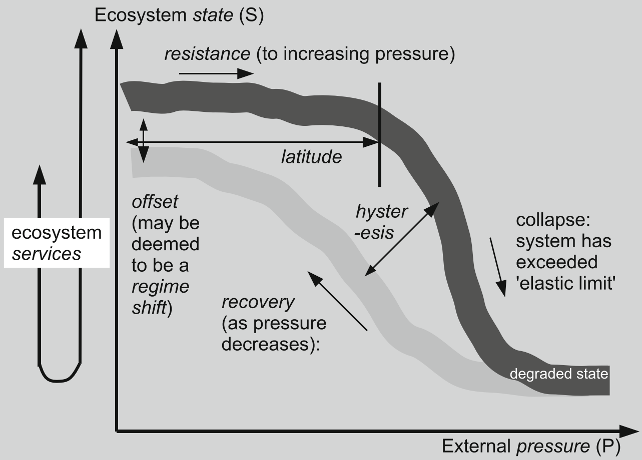


**Fig. 2.4** A conceptual model of changes to the state of a system with increasing pressure (Source: combines ideas in pressure-state diagrams by Tett et al. (2013) and Elliott et al. (2007)

The systems-based approach explicitly recognises that most systems are complex and display inevitable uncertainty in the links between causes and effects. AM is a pragmatic way to achieve national and social-ecological objectives in the face of these high levels of uncertainty. It treats management actions in the coastal and marine system as ‘experiments’ based on the principle of ‘learning by doing’. The MSFD employs this approach through their cycle of target setting, planning, implementation and review of marine strategies (Mee et al. 2008). AM can accommodate ‘surprise’ events by encouraging approaches that build system resilience to withstand stress and shock and help maintain basic ecosystem functionality (Mee 2005). AM sets both a long term vision (supported by measurable environmental targets, e.g. Good Ecological Status (GEcS) and Good Environmental Status (GEnS) and their indicator sets respectively in the WFD and MSFD), as well as short term goals for ecosystem improvement (see Fig. 1.2). In the case of the MSFD, the long term objectives are supranational (regional sea or EU-wide level), whereas the short-term goals are set through national planning processes and function like ‘stepping stones’ towards the longer term ones. For ‘learning’ to occur, it is important that appropriate indicators are formulated (see Chap. 5) and progress towards all targets is monitored carefully and communicated in a transparent manner, allowing objectives and goals to be adjusted from time to time as more information becomes available. The overall vision (GEnS in the case of the MSFD) reflects human values towards the marine environment; the term ‘Good’ is a human-centric one and the measurement of value is critically important (Mee et al. 2008; Borja et al. 2013).

The linkages between catchment-coastal processes and systems, the influence of climatic change and the impacts on and feedback effects from socio-economic activity all need to be better understood if we are to fully characterise the coastal ecosystem services stocks and flows and assign appropriate values. The incorporation of these data into DSSs, it can be argued, would facilitate better policy outcomes. The values that need to be incorporated are not confined to economic monetary-based values, but encompass a plurality of values expressed in a number of ways, both quantitative and qualitative (Turner 1999; Chan et al. 2012).

A particular feature of the coastal zone is the so-called ‘legacy’ problem with ‘lock-in’ effects and the consequential increased risks and vulnerability to flooding and erosion that it poses. Coastal situations are often conditioned by a historical legacy burden, e.g. the build-up of contaminants in estuarine and coastal sediments from past industrial and urban development; the impact of physical structures and reclamation activities themselves; chronic eutrophication pressures from intensive agriculture or inadequate sewage treatment provision; or depletion of fish stocks by long established fishing practices. This legacy also extends to entrenched historical and cultural use patterns and expectations which may not be environmentally or economically sustainable but can be difficult to alter. Thus the impacts on the stock and flow of ecosystem services can be significant, complex and difficult, and costly to ameliorate, often requiring catchment or wider scale action, combined with continual stakeholder engagement.

Social and economic parameters also change as the process of globalisation continues and its pace of change escalates. Driven by the trends in international trade and finance (and fuelled by, among other factors, persuasive advertising industries) coastal zones are at the forefront of a whole suite of continuously evolving impacts with extensive and significant environmental consequences, e.g. from loss of valuable habitats due to port and navigation channel enlargement and energy resource exploitation, to fishing pressures and tourism over-crowding (Mee 2012). Given the plethora of drivers across different spatial and temporal scales, any DSS must be anchored to a systematic scoping process and be tempered by a ‘learning by doing’ management philosophy that is flexible enough to redo analyses if expectations are not met (Mee 2005). The ultimate goal is to achieve a sustainable and productive utilisation of the available resource system (stock and ecosystem services flow) and the avoidance of irreversible system changes or collapse with consequent high human welfare losses.

## 2.4 Ecosystems Processes and Services: Concepts

Coastal ecosystem natural capital **stocks** (the ecosystem structure and processes and links to the abiotic environment) possess high biological productivity and provide a diverse set of habitats and species, with a consequent **flow** of ecosystem services (the outcomes from the functioning of ecosystems) of significant **value** (benefits) to human society (Barbier et al. 2008). From this valuation perspective, a combination of basic ecosystem structure, processes and 'intermediate' services provide 'final' services of relevance to human welfare ('benefits') as goods that are consumed by humans or essential for human survival (MEA 2005). Ecosystem services benefits are the 'exports' from the ecosystem sector to the human economic sector (Banzhaf and Boyd 2012). Complementary assets (e.g. time, energy, finance or skills) also usually have to be combined with the natural capital to yield benefits. Following the UK NEA (2011) and UK NEAFO (2014) conceptual framework for ecosystem services assessment, the outcomes from the functioning of ecosystems have been generically labelled 'goods' which refer to a range of human welfare benefits derived from the flow of final services provided. But the scope of the delivered final ecosystem services (and therefore the valued goods and benefits) is very wide from food to carbon storage, coastal protection, sea defence, tourism and nature watching (Balmford et al. 2011; Bateman et al. 2011). Figure 2.5 illustrates the conceptual framework begining with boundary conditions. It makes a clear distinction between stocks and flows, and between basic processes, intermediate and final services, and it introduces that values are bounded by beneficiaries groups.

Many definitions and classification schemes for ecosystem services exist (Costanza et al. 1997; Daily 1997; Boyd and Banzhaf 2007). One of the most widely cited is the Millennium Ecosystem Assessment definition (MEA 2005), which describes ecosystem services as 'the benefits that people obtain from ecosystems'. It classifies ecosystem services into: *supporting* services (e.g. nutrient cycling, soil formation, primary production), *regulating* services (e.g. climate regulation, flood regulation, water purification), *provisioning* services (e.g., food, fresh water), and *cultural* services (e.g. aesthetic, spiritual, recreational and other non-material benefits). This framework provides a platform for moving towards a more operational classification system which explicitly links changes in ecosystem services to changes in human welfare. By adapting and re-orienting this definition it can be better suited to the purpose at hand, with little loss of functionality. Wallace (2007), for example, has focused on land management, while Boyd and Banzhaf (2007) and Mäler et al. (2009) take national income accounting as their policy context.

For economic and social valuation purposes the definition proposed by Fisher et al. (2009) clarifies the distinction between ecosystem services and benefits: *ecosystem services are the aspects of ecosystems utilised (actively or passively) to produce human well-being*. Fisher et al. (2009) see ecosystem services as the link between ecosystems and things that humans benefit from, not the benefits themselves. Ecosystem services include ecosystem organisation or structure

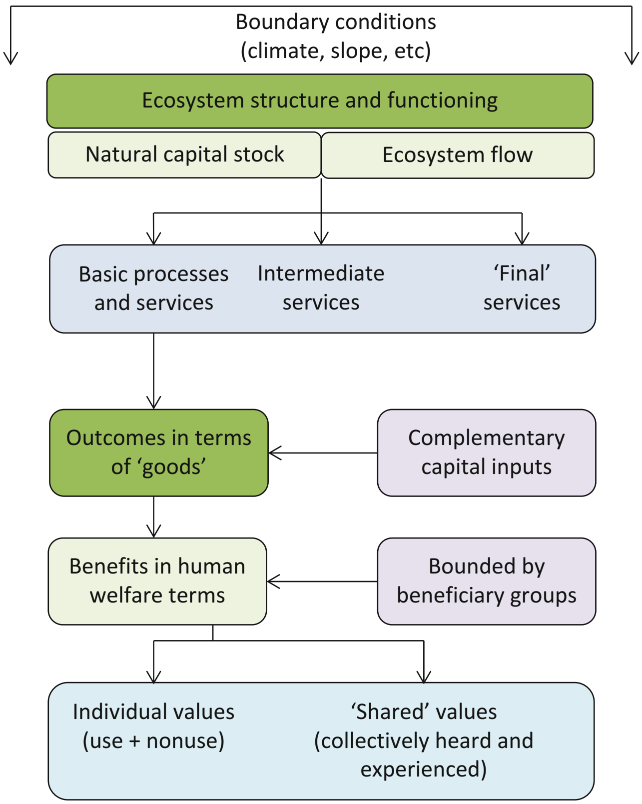


**Fig. 2.5** Ecosystem services conceptual framework

(the ecosystem classes) as well as ecosystem processes and functions (the way in which the ecosystem operates). The processes and functions become services only if there are humans that (directly or indirectly) benefit from them. In other words, ecosystem services are the ecological phenomena, and the good (benefit) is the realisation of the direct impact on human welfare. The key feature of this definition is the separation of ecosystem processes and functions into intermediate and final services, with the latter yielding welfare benefits (see Fig. 2.5).

The term 'intermediate services' should not be interpreted as signifying lesser significance but rather as a necessary signal in order to clearly demarcate (in valuation terms) final services and provide technically-correct guidance to avoid double counting when services are valued in economic or non-monetary terms (Fisher et al. 2009). It is changes in the provision of final ecosystem services that we are interested in measuring and incorporating into economic and social analysis.

The assessment and valuation of ecosystem stock and flow situations is therefore not a straightforward task. The monetary valuation of stocks and flows in particular is complex and has to rely on a range of accounting and socio-economic approaches, together with an underlying natural science understanding (see Chap. 4). Some services will not be amenable to monetary valuation, and the use of coastal resources and their conservation is often highly contested involving different interest groups. Coastal areas are also socio-cultural entities, with specific historical conditions and symbolic significance. The values expressed for such cultural entities may well manifest themselves through collective social networks such as groups, communities and even nations. They may not be best identified through an individual's monetary valuation, but through group deliberation and shared values in quantitative or qualitative terms, or through other evidence sources, e.g. archives (UK NEAFO 2014). We take a closer look at 'shared values' in Chap. 4.

## 2.5 Coastal Ecosystem Processes and Ecosystem Services: Classification

A classification of coastal and marine ecosystem services is provided in Fig. 2.6, whilst Table 2.1 provides a set of definitions supporting this classification, adapted from, inter alia, de Groot et al. (2010), Böhnke-Henrichs et al. (2013), Hattam et al. (2015) and the UK NEA (2011, 2014). The categories and definitions are part of an active research topic and therefore in a process of on-going refinement and improvement. For example, some of the definitions of the cultural ecosystem services in Table 2.1 may overlap, as indicated by footnotes. The overlap should be considered in the assessment of net impacts on well-being.

The set of definitions focuses on those ecosystem services that relate to coastal and marine (C&M) biota, in some cases supported by or dependent on abiotic processes or structures of the ecosystem. Coastal and marine (C&M) biota refers to all living components of the coastal and marine environment including all flora, fauna, algae, bacteria, etc. However, the classification excludes goods and services derived from the abiotic and physic-chemical environment such as the provision of materials for mining, e.g. minerals, oil, marine aggregates, etc.

The definitions support the ecosystem services categories in Fig. 2.6 and were developed for the assessment of (dis-)benefits set in a CBA framework. However, the use of the categories may be adapted to different policy contexts when there is a pre-defined policy objective that society has agreed to. For example, as indicated by a star (*), the policy appraisal concerns a cost-effectiveness analysis and the aim is to manage the coastal ecosystem towards that objective at the lowest possible cost; the emphasis shifts to understanding the ecosystem functioning that supports the policy. If the policy appraisal aims to assess whether costs of measures are (dis-)proportionate, we move back into a CBA framework, and the final ecosystem services related to the standard as well as potential other co-benefits have to be assessed.

Coastal and marine ecosystems are dynamic systems made up of living and non-living components that interact with each other by way of complex exchanges of energy, nutrients and wastes. These exchanges are driven by the physical, chemical

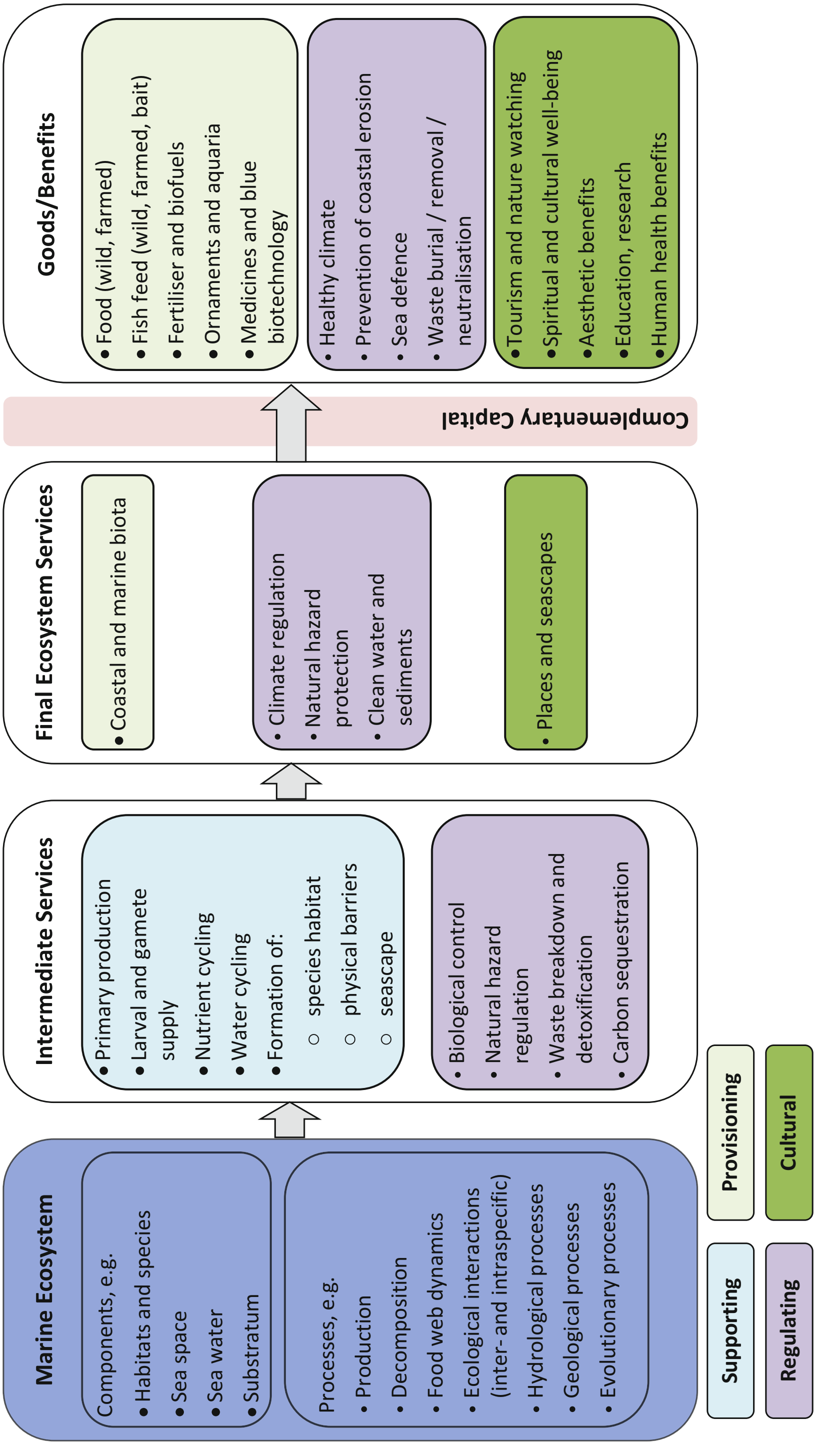


**Fig. 2.6** Ecosystem service classification

**Table 2.1** Definitions of intermediate and final ecosystem services and associated goods and benefits

| | Definition | Example |
|---|---|---|
| **Intermediate services** – *those services whose ecological processes and functions support all life, and, by definition all other services* (UKNEA 2011). *They may include non-fundamental ecosystem processes and functions.* | | |
| Primary production | The synthesis of organic matter by C&M biota from atmospheric or aqueous carbon dioxide | Quantity and/or quality of primary production from a given area of saltmarsh or volume of seawater |
| Larval and gamete supply | The production and supply of larvae and gametes from C&M biota | Quantity and/or quality of larvae or gametes supplied to a given coastal or marine location |
| Nutrient cycling | The influence of C&M biota on the movement or exchange of organic and inorganic matter | Change in the concentration of nitrates/phosphates in coastal or marine waters/sediments |
| Water cycling | The influence of C&M biota on the movement or exchange of water between the C&M environment and adjacent environments (including the atmosphere) | Change in the amount of water retained within a coastal saltmarsh or reedbed |
| Formation of species-habitat | The contribution of C&M biota to habitat formed by one species but providing suitable niches for other species | Change in the formation of mussel beds, kelp forests, cold-water coral reefs |
| Formation of physical barriers | The contribution of C&M biota to the formation of physical barriers | Changes in reef extent by reef-forming organisms (e.g. *Sabellaria spp.*), impacting on the local hydrographic regime |
| Formation of seascape | The contribution of C&M biota to supporting the formation of different coastal and marine views ('seascapes') | Changes in area per type of seascape e.g. algae-covered rocky shore, kelp forest |
| Biological control | The contribution of C&M biota to the maintenance of population dynamics, resilience through food web dynamics, disease and pest control | Oystercatchers controlling intertidal cockle population numbers; cleaner fish (e.g. ballan wrasse) removing sea lice from salmon |
| Natural hazard regulation | The area of suitable C&M habitat which is available to absorb energy | Width or area of saltmarsh/mudflat/reedbed/sea grass |
| Waste breakdown and detoxification | The presence of C&M biota which have the potential to remove anthropogenic contaminants and organic inputs | The presence of reedbeds, mussels beds, etc. |
| Carbon sequestration | The net capture of carbon dioxide by C&M biota | Change in the net amount of carbon stored within an area of coastal saltmarsh within a certain period |

(continued)

**Table 2.1** (continued)

| | Definition | Example |
|---|---|---|
| **Final services** – *the outcomes from ecosystems that directly lead to good(s) that are valued by people* (UKNEA 2011) | | |
| C&M biota | The flow of C&M biota | Change in the quantity/quality of North Sea cod population, seaweed stock, genetic material, ornamental materials, etc. over time |
| Climate regulation | The contribution of C&M biota to the maintenance of a favourable climate through the regulation of greenhouse gases | Healthy climate |
| Natural hazard protection | The contribution of C&M biota to the dampening of the intensity of environmental disturbances such as storms, flooding and erosion | The reduction in the intensity of environmental disturbances resulting directly from C&M ecosystem structures such as saltmarsh and sea grass beds |
| Clean water and sediments | The contribution of C&M biota to the provision of clean water and sediments | Quantity of waste (tonnes) that is recycled or immobilised by C&M biota over a period of time |
| Places and seascapes | The contribution of C&M biota to places and seascapes | Number of coastal sites designated for internationally important seabird colonies |
| **Goods/benefits** – *all use and non-use, material and non-material outputs from ecosystems that have value for people* (UKNEAFO 2014) | | |
| Food (wild, farmed) | Extraction of C&M biota for human consumption | Tonnes of cod landed for human consumption |
| Fish feed (wild, farmed, bait) | Extraction of C&M biota for non-human consumption | Tonnes of sandeel harvested to be processed into fishmeal; volume of mackerel caught for use as bait in crab/lobster pots |
| Fertiliser and biofuels | Fertiliser (biocides) or energy sourced from C&M biota | Biomass of algae harvested to be processed into fertiliser |
| Ornaments and aquaria | Extraction of C&M biota for decoration, fashion, handicraft, souvenirs etc. or for display in aquaria | Number of European lobster extracted for display in aquarium exhibits; amount of skins, shells, corals, plants, extracted from the C&M environment for decoration, fashion etc. |
| Medicines and blue biotechnology | Extraction of C&M biota in order to produce medicines, pharmaceuticals, animal and plant breeding and biotechnology | Marine-derived pharmaceuticals such as the use of sea lettuce (*Ulva lactuca*) in cosmetic and personal care items including make-up remover, shampoo and shaving lotion |
| Healthy climate | Improvements to human well-being as a result of a healthy climate | Bodily harm avoided as a result of natural carbon sequestration by C&M biota |

| | | |
|---|---|---|
| Prevention of coastal erosion | Reduction in hazards resulting from the natural prevention of coastal erosion by C&M biota | Prevention of gradual damage to property and land by dunes |
| Sea defence | Reduction in flooding related hazards as a result of the natural protection provided by C&M biota | Saltmarsh providing a natural form of sea defence in the coastal region |
| Waste burial/removal/ neutralisation (*) | Contribution of C&M biota to achieving pre-defined policy standard related to waste levels in water by natural waste burial, removal and neutralisation | Natural waste breakdown by C&M biota such as reedbeds – in contexts in which pre-defined regulations/ standards apply |
| Tourism and nature watching | Benefits from recreation, leisure driven by coastal seascapes and their associated C&M biota | Benefits associated with watching seabirds, marine mammals |
| Spiritual and cultural wellbeing[a] | Ability to enjoy preferred lifestyle, culture, heritage, folklore, religion, creative inspiration, and spirituality; sense of place (use-driven) based on ecosystem aspects | The importance of C&M environments in cultural traditions (e.g. traditional cobble fisheries on east coast) or folklore (e.g. sea shanties) |
| Aesthetic benefits[b] | Enjoyment of the beauty of C&M seascapes | Higher house prices in coastal locations |
| Education, research[c] | Enjoyment of formal and informal education, research and science, knowledge systems, etc. in which C&M biota play a role and are a source of information | Amount of funding secured for research on C&M biota; number of scientific research papers published which focus on C&M biota |
| Health benefits[d] | Human physical and psychological health benefits associated with the direct and indirect use of the coastal and marine environment | Increased psychological well-being from direct or indirect experience of the C&M environment; increased physical well-being resulting from engagement with C&M environment, e.g. exercise. |

[a]Overlap with recreation and human health related goods and benefits categories should be checked and where possible avoided in the valuation assessment. Similarly, there is some ambiguity in the distinction between art and design and aesthetic benefits
[b]Aesthetic benefits may also be reflected in tourism and nature watching and ornamental values
[c]Overlap with the category medicines and blue biotechnology should be avoided in the valuation assessment
[d]Overlap with tourism and nature watching, spiritual and cultural wellbeing, medicines and food

and biological processes or attributes that are characteristics of a particular ecosystem and its functioning. The functioning of coastal and related marine areas is maintained through a diversity of ecosystems, e.g. salt marshes and other wetlands, sea grasses and sea weed beds, beaches and sand dunes, and estuaries and lagoons. This natural capital stock provides a range of processes such as nutrient and sediment storage, water flow regulation and quality control and storm and erosion buffering (see Fig. 2.6.) (Crossland et al. 2005). Coastal and marine ecosystem processes and functions can, for example, be grouped into four broad categories, which broadly map on to the processes, 'intermediate services' and final services concepts in the classification system adopted here to facilitate monetary valuation:

- **Purification and Detoxification:** filtration, purification and detoxification of air, water and soils;
- **Cycling Processes**: nutrient cycling, nitrogen fixation, carbon sequestration and soil formation;
- **Regulation and Stabilisation**: pest and disease control, climate regulation, mitigation of storms and floods, erosion, regulation of rainfall and water supply; and
- **Habitat Provision**: refuge for animals and plants, storehouse for genetic material.

An intermediate service is one which influences human well-being indirectly, whereas a final service contributes directly. Classification is context dependent, for example, clean water supply is a final service to a person requiring drinking water, but it is an intermediate service to a recreational angler. Importantly, a final service is often but not always the same as a benefit. For example, recreation is a benefit to the recreational angler, but the final ecosystem service is the provision of the fish population. This examples shows how the classification approach used here seeks to provide a transparent method for identifying the aspects of ecosystem services which are of direct relevance to economic valuation, and critically, to avoid the problem of double-counting.

The policy context to which the analysis relates is also very important and influences the way in which the ecosystem classification can be utilised. To take an example, an estuary and coupled catchment characterised by, among other economic activities, intensive agricultural regimes. The estuary has extensive wetlands, salt marsh and mudflat areas which can provide a set of ecosystem services. Given the impacts of intensive agriculture, for example, heavy nutrient N and P runoff, the wetlands can provide valuable services such as nutrient cycling. If for example, national policy includes a provision to increase wetland habitat and the services it provides, in a CBA of this policy option the nutrient cycling service provided by the wetlands would be treated as an intermediate service contributing to the provision and value of final services, e.g. better water quality. This cleaner water may then lead to enhanced recreation and amenity benefits, or improved fisheries productivity, which can be assigned a monetary value.

A change in the policy context, however, can change the way in which the ecosystem service classification is used. Assume the estuary is already subject to an official (national or international) water quality standard provision, which it is failing and the policy option under consideration is how best to meet the standard. Now cost effectiveness analysis (CEA) would be deployed to determine the least cost way of achieving the pre-existing water quality standard. In this context the nutrient cycling service provided by an increase in the wetlands via re-creation, would be focused on and the costs of wetland re-creation or establishment would be compared with, for example, the cost of enhanced sewage treatment processes and facilities, or changes in agricultural regimes imposed on farmers (e.g. nitrogen zoning).

## 2.6 Decision Support System (DSS): Practice

The DSS needs to be composed of a number of sequential (depending on the exact policy issues and context) but overlapping components:

- An interdisciplinary scoping exercise to establish or model baseline ecosystem and co-evolving socio-economic systems conditions and trends, together with a focused attempt to identify ‘key’ policy contexts and issues;
- The selection and development of appropriate functionally related indicators of ecosystem state (the stock position) and changes in services (the flow position) supply over time;
- A futures assessment through the use of scenarios covering prevailing conditions and alternative future states;
- The deployment of ‘tools’ (including models) to enable a scientific, economic and social appraisal of policy options, including distributional concerns and the use of deliberative methods and techniques to foster social dialogue across interest groups;
- Appropriate formatting and presentation of appraisal data, assumptions and findings into an evidence base; and
- Setting up adequate monitoring and review procedures.

We look at the main components of the DSS below.

## 2.7 Scoping Environmental Change in Coastal Zones

The underlying activity-pressure-impact chain characteristic of coastal zones (Crossland et al. 2005) can be been expanded to form the Drivers, Pressures, State changes, Impacts and Policy response (DPSIR) framework. Further, because of the continuing confusion between the S being State and State Change and the I being Impact (on the natural system) and Impact (on the human system) (Atkins et al. 2011), the original formulation has been further modified to the DPSWR approach where W replaces I as impact on human welfare (Turner et al. 1998; Cooper 2013).

The DPSI(W)R framework can help to scope in a standardised fashion policy and management contexts in order to get a better understanding of this environmental change process and what it means in ecosystem service terms. This established scoping methodology can combine data about environmental change drivers and pressures with causal mechanisms which result in environmental state changes, and impacts associated with human welfare gains and losses. Feedback loops between policy responses and other components of the change process are also encompassed within the approach to avoid overly linear thinking as individual and societal innovation often occurs in a non-linear and in sometimes surprising ways. The approach first developed to classify and organise environmental indicators has proved to be a useful heuristic in wider environmental management contexts (Turner et al. 1998). The scoping exercise has to be sufficiently robust to capture all the main drivers of change and behaviour incentives across multiple actors, jurisdictions and agencies. While it is the case that coastal and marine system issues can be complex and that a range or combination of variables influence human interest individuals and groups, under any given governance system, partial decomposition of problems is possible (Ostrom 2007). However, the information provided by the DPSWR process will require further refinement to include a specific focus on ecosystem services and in order to highlight 'key' contexts and issues. The Impacts or Welfare stage needs to be specifically calibrated in terms of ecosystem services and interactions and feedbacks (Kelble et al. 2013).

The *framing* of a policy issue is necessary in order to enable identification of appropriate decision support processes and suitable policy instruments. Typical contemporary policy issues within the regional seas and coastal zones, and which are at the core of the need for better policy tools and governance regimes are diverse. For example, increase in human population size may lead to increase building activities in risk prone zones, including more artificial defence structures, which in turn can lead to the destruction of natural habitat such as saltmarsh, or arable land. Aquaculture and wind farm development may lead to pollution and loss of habitat and biodiversity, which consequently affects goods and benefits such as fisheries and recreation, either directly or by providing a stepping stone for invasive species.

Figure 2.7 illustrates the DPSWR framework in standard form, including feedback loops between Responses, and Drivers and Pressures, and recognition that there are natural pressures on ecosystems, which can lead to State Changes. Defining boundaries requires due care and attention, because pressures on the system can be locally, regionally or internationally managed pressures (power generation, fisheries, etc.), or exogenic unmanaged pressures (climate change, volcanic eruptions, geomorphic isostatic readjustment, etc.). The latter case, in contrast to the former, is one of bounded rationality (i.e. taking action with limited information on a 'learning-by-doing' basis) since their complexity is such that we do not yet have sufficient knowledge of how and why change occurs in such systems, and so our response is not of the management of the pressure but of the consequences of that pressure; in the case of endogenic managed pressures, we may be able to manage both the causes and the consequences (Atkins et al. 2011).

The DPSWR framework has been widely used to assess and manage the impact of policy changes and associated problems; however, a change is evident in recent

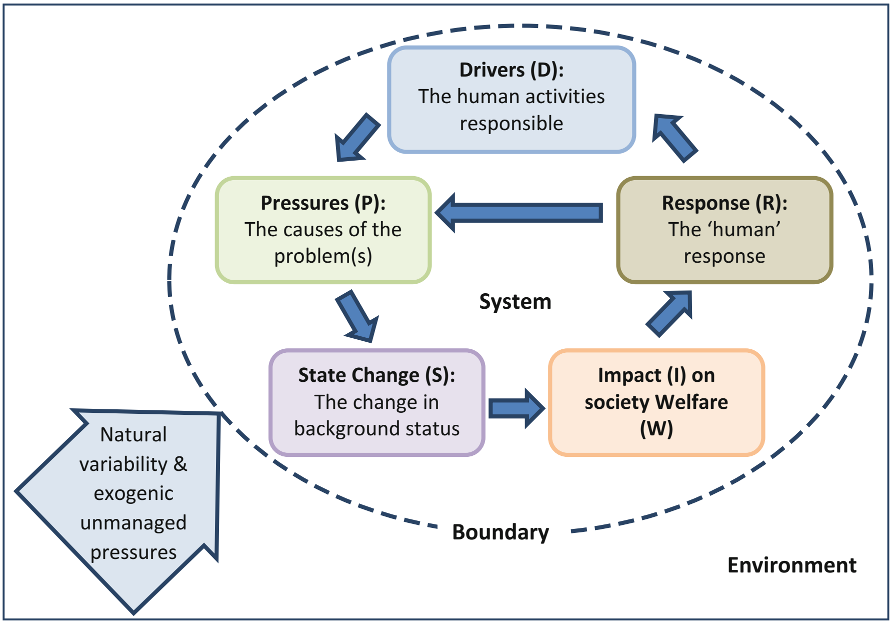


**Fig. 2.7** The DPSI(W)R framework. DPSI(W)R can be explicitly focused on ecosystem services through the S and I(W) stages

applications of the approach: an expert-driven, evidence focused mode of use is giving way to the use of the framework as a heuristic device to facilitate engagement, communication and understanding between different stakeholders (Cooper 2013; Kelble et al. 2013). The DPSWR has been used to categorise indicators of environmental change and the application of scenario analysis to the framework can also be a useful way to further embed the DPSWR into the DSS for management.

## 2.8 Indicators

The future challenge in the EU is the joint implementation of the WFD and MSFD with the former focusing on the protection of the system according to chemical status and five biological quality elements (four in the coastal zone), whereas the MSFD focuses on 11 descriptors, each of which can be linked to show a hierarchy (see Borja et al. 2013). The WFD is regarded as a 'deconstructing structural' approach, whereby the indicators are more easily related to the structural ecosystem components, whereas the MSFD apparently will relate to functioning of the system and a more well-defined set of pressures along the activity-pressure-impact chain (Borja et al. 2013).

The MSFD has stimulated new work into appropriate indicators linked to the 11 descriptors of the environmental change process as it affects coastal and marine ecosystems (stock and flow) and their services provision. Functional indicators are required, for example, across media, spatial location, hydrological function and biological function. Chapter 5 presents an overview of the indicators that are being developed for the assessment of coastal and marine ecosystems.

## 2.9 Coastal and Marine Futures Scenarios

While future uncertainty will always remain problematic, scenario analysis (typically based on a ‘business as usual’ (BAU) baseline trend assessment, against which a range of different future paths can be assessed) offers a way of coping with uncertainty and provides policy relevant decision information on plausible future states of the world. Chapter 8 discusses possible scenarios for coastal and marine habitats in more detail.

## 2.10 Models

An important component of the AM approach and DSS is the development of models. A number of different types of models can be deployed, ranging from formal scientific models of land use change in catchments with links via nutrients and other factors into models for estuaries and coastal waters, to conceptual models which are simple ways of highlighting and eliciting human perceptions about how a system functions. The latter allow a dialogue between experts, stakeholders and the public which conveys information, identifies ‘contested’ issues and provides the opportunity to reinforce or modify perceptions and expressed values (Turner 1999). Underpinning the approach is a requirement to collect empirical data and metadata on ecosystem functioning and service provision, together with an understanding of the distribution of ecosystem benefits (who gains or losses in any environmental change situation) and governance contexts. We review the available models for coastal and marine systems in Chap. 3.

## 2.11 Economic and Social Appraisal

The application of economic and social appraisal of projects, policies, programmes or courses of action in the coastal context can only take place after policy issues have been identified and highlighted within given spatial and temporal scales, and scenarios and evaluative criteria have been established and legitimised within the dialogue process. Once agreed, the policy issues and scenarios chosen then provide the backdrop and framework within economic and social appraisal can take place. However, this is not a one-way process. Ideally, feedback should occur between all stages of the assessment process and the deliberative procedures set up with stakeholders, since concerns that are thrown up by the dialogue can help to refine the policy issues, leading to acceptable interventions and scenarios that resonate with most stakeholders and interest groups.

### 2.11.1 Environmental Impacts, Welfare and Economic Values

Once policy issues and scenarios are established, the next stage of the process is to determine all the relevant impacts that will take place under the scenarios considered. These impacts relate to changes in the provision of final ecosystem services and goods (which could include, for example, the carbon storage functions of coastal mudflats) and other, more conventional goods (such as commercial fish catch or shellfish harvested from coastal mudflats). Primarily, economic assessments are concerned with those impacts on goods that can be valued in monetary terms. However, this does not mean that all impacts can be incorporated into such an analysis – it may not be possible to value all impacts in this way, because of practical or ethical considerations. Hence we consider that economic assessment provides just one strand of an overall integrated (sustainability) analysis, with other strands being supplied by assessments and techniques from social, deliberative and ecological perspectives (such as multi-criteria analysis (MCA), participatory GIS, deliberative fora, deliberative monetary valuation). It is also the case that the sustainable provision of the flow of final services and related goods and benefits depends on the maintenance of system-wide ecosystem processes with adequate carrying capacity and resistance and resilience characteristics. Conventional economic analysis based on marginal changes is not well suited to identifying and encompassing system unsustainability.

The core of the economic assessment process is to determine how changes in ecosystem services provision are translated into changes in welfare (which can be positive or negative, i.e. benefits or costs). This is achieved by placing a monetary value on each of those changes and aggregating these values together to arrive at an overall change in value for the environmental and policy scenarios considered. Chapter 4 discusses the non-market valuation theory.

### 2.11.2 Policy Response Interventions

Policy response interventions usually fall into a number of categories:

- **Mitigation of pollution and resource overexploitation problems** – the ecosystem service benefits that need to be valued are related to damage reduction and/

or restoration measures, e.g. reduced flooding damage or sedimentation in navigation channels or restoration of wetlands, water treatment investment, changing farming practices in the catchments, etc.;

- **Compensation for losers measures** – these may be financial as in the case of coastal erosion problems in England and Wales with, for example, the Pathfinder experimental scheme in which local authorities offered to pay 40–50 % of the theoretical value of properties threatened by coastal erosion, based on the value of similar properties inland; or environmental compensation under a precautionary principle, safe minimum standards approach, which can include project management on a portfolio basis (Barbier et al. 1990) with so-called 'shadow' or 'compensating' projects; or habitat equivalency compensation measures (Roach and Wade 2006);
- **Enhancement of marine and coastal zone ecosystem services** – actions which provide an increased provision of benefits, e.g. adaptation to change (see Box 2.1), which increases the output of some good such as creation of artificial reefs to provide erosion protection, or fisheries habitat and nursery which enhance productivity of the stock, or the reduction of conflicts among or between various users of coastal ecosystems via pricing schemes or zoning;
- **Preservation of unique marine and coastal ecosystems** – the benefits stem from setting aside and managing particular areas via Marine Protected Areas (MPAs) in order to preserve the natural ecosystem can be twofold. Use benefits e.g. visits to a nature reserve to observe nature or take photographs, etc.; and non-use benefits which are not related to visits but encompass option or existence values. The non-use values here relate to motivations which seek to conserve ecosystems for future use (insurance value) and the continued presence of species and habitats from which people derive passive welfare. Shared values will also be important in this category; and
- **Joint usage benefits –** within this last category of interventions, marine spatial planning and zoning have recently come to the fore, including the search for joint usage benefits. The UK Marine Policy Statement, for example, contains the following statement: *"The Marine Plan should identify areas of constraint and locations where a range of activities may be accommodated. This will reduce real and potential conflict, maximise compatibility between marine activities and encourage co-existence of multiple users"*.

There is a need to better understand the barriers to the achievement of joint net benefits, i.e. co-location situations in which multiple users or activities share the same impacts footprint (MMO 2013). The decision to locate any given economic activity in a particular marine space will be conditioned by a range of factors. At the core of this process will be an assessment of financial profit or loss potentially available to the economic agent (individual or firm) involved. However, the decision will be further constrained by existing and possible future legislation and regulation and wider social and environmental issues, such as, for example, loss of local employment or cultural identity when fishing activities are curtailed or lost; and environmental impacts including use and non-use loss if biodiversity is reduced. So the impacts (footprint) of co-location can be multidimensional and any assessment method must be able to accommodate this diversity. The Balance Sheets Approach framework set out in Sect. 2.13 seeks to meet this need.

Two economic concepts, externalities and joint production, can be used in order to formally distinguish between the different possible categories of co-location. The 'technological externalities' concept refers to the indirect effect of an economic agent's consumption or production activity on the products, consumption or welfare of a different economic agent, and where the effect does not work through the price system. Externality effects can be positive or negative and quite diverse, including forms of pollution or contamination and interaction between different production activities. In the latter context, so-called 'joint production' cases can be identified. So multiple products may be produced under separate production processes, or several outputs may be produced from a single production process.

Three distinct categories of co-location for a given marine space can be identified using the economic concepts of externalities and joint production (see also Lester et al. 2013):

- No co-location – situations in which there are no feasible joint production possibilities and candidate activities generate negative externality effects; e.g., offshore wind farms and demersal fishing with beam trawls cannot take place at the same location;
- Horizontal co-location – joint production possibilities exist and the candidate activities do not generate significant negative externality effects; e.g., offshore wind farms and open water aquaculture can go together; and
- Vertical co-location – no joint production possibilities and no negative externality effects; e.g., recreational fishing or boating in a MPA but limited to certain times of the year to protect fish spawning or biodiversity.

## 2.12 Balance Sheets Approach Format

Finally, we turn to the question of how appraisal might be sequenced and how information can best be collated, interrogated and presented to policymakers. Building on the work of the UKNEA (2011), the UK NEAFO (2014) has developed the Balance Sheets Approach as a means constructing as robust an evidence base as is feasible to underpin the policy process. It is therefore both a process and a tool and forms one component of an overall DSS.

If CBA or related methods are to continue to play a role in the policy process, then a more explicit focus on distributional issues (i.e. who gains and who loses from environmental change and consequent policy responses) is required. A two stage approach needs to be adopted in which the spread of costs and benefits across different affected individuals and groups in society needs to be accounted for, and a weighting procedure applied. Project appraisals funded by economic development agencies have routinely included distributional weights but this practice has not been common place in other public sector applications. As a minimum, the way in which the CBA 'accounts' are set out and formatted needs to be changed in order to incorporate and highlight financial transfers and the distributional impact of costs and benefits across stakeholders. Krutilla (2005) has set out a tableau format which disaggregates the benefits and costs of a project or policy among stakeholders and records all inter-stakeholder financial transfers. It also serves to illuminate key issues such as the level of aggregation adopted and the project or policy accounting boundary.

Changing the accounts format is a necessary first step, but Kristrom (2005) has gone further and put forward a 'hierarchy of options approach' in which explicit distributional weighting is applied, based on a rule that requires higher weights on all costs and benefits accruing to socially disadvantaged or below average income groups. Alternatively, explicit distributional weights can be introduced to reflect the degree of inequality aversion present in society, by examining past public policy decisions, or the prevailing marginal rates of income tax (Atkinson et al. 2000).

Any DSS that is put in place to assist in evaluating the gains and losses involved in marine planning and management will need to encompass a wide diversity of impacts and different stakeholder perspectives. The Balance Sheets Approach (see Fig. 2.8) is a pragmatic attempt to provide a framework within which the complexity of real world decision making and trade-offs can be examined. It sets out three complementary components (balance sheets) which can be seen as 'roughly comparable' sets of findings with overlaps and linkages. The aim would therefore be to determine the 'best' combination of data, methods and analysis, depending on the actual activity and context under appraisal (Turner 2011). The different policy contexts are illustrated in the figure along the horizontal axis in terms of a spectrum between two polar opposites: slow and simple versus complex and dynamic change processes.

The complexities and the non-commensurate values that characterise the real world political economy of 'contested' natural resource allocation and trade-offs are clearly illustrated in European fisheries policy. The annual fisheries negotiations in Brussels try to set rules for fair access to fish stocks. Scientists have recommended total limits to catch to avoid fishing beyond levels that the stock will support. Ministers then meet together at the annual Fisheries Council to set pragmatic rules of access based on instruments such as gear type, number of vessels, days at sea and total allowable catch. In the past, ministers have often negotiated catch allocations that exceed the advice of their own scientists. One reason for this is the non-commensurability of the currencies used by different sectors engaged in the process, each of which seeks to archive 'sustainability'. The fleet owners seek to sustain profits (market values, that can be subjected to a CBA); local political representatives seek to optimise or conserve employment and multiplier effects at the community level (measured as jobs and susceptible to financial impact analysis at a local scale); and conservationists emphasise non-use values and ethical considerations (more amenable to deliberative methods including MCA). The Minister at the Council tries to balance these interests but, without an effective analytical framework, and with competing claims from other ministers, the likelihood of

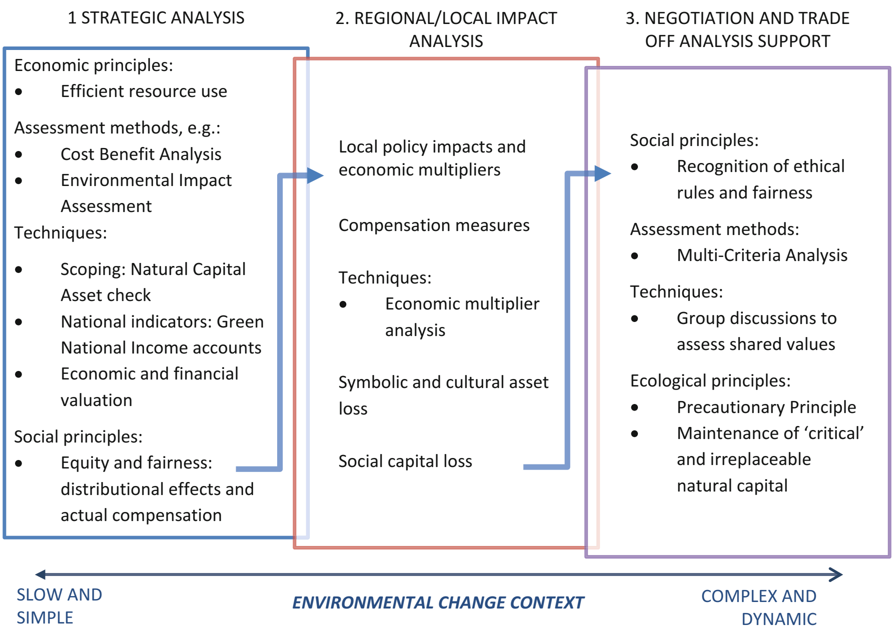


**Fig. 2.8** Balance sheets approach. Assessments progress through the sheets as the social and environmental context become more complex and dynamic

success is quite low. The next reform of the EU Common Fisheries Policy will try to improve this situation by following the 'Ecosystem Approach' that recognises humans as an intrinsic part of the system and that total allowable catch or damage to habitats and non-target species cannot be permitted to exceed ecosystem limits.

Another policy context concerned with coastal protection and sea defence also highlights the 'wicked' characteristics common in many environmental management situations. Over the past decade or so UK government policy in terms of future investments in coastal management has been re-orientated away from a 'hold the line' philosophy and towards a more flexible approach. The new approach has included coastal realignment schemes in selected locations and also a greater recognition of coastal processes such as erosion and subsequent beach replenishment. But the DSSs and policy planning had not been sufficiently adjusted before the headline strategic policy shift became widely publicised and stakeholder concerns were raised. Poor policy support sequencing has meant that difficult 'local' policy impacts and controversies have been raised and policymakers have been slow to respond. Thus the switch towards a more flexible coastal management regime can be justified on overall cost grounds and national strategic requirements, together with a precautionary approach to possible climate related sea level rise and storm intensity and frequency predictions. But the distributional consequences should have been recognised in advance of the policy switch, and mitigation measures should have been in place, as well as a more targeted information and awareness campaign. Instead the agencies involved have had to play catch up, following numerous stakeholder protests and campaigning and wide press coverage. So acceptable 'compensation' measures for the 'losers' in any given coastal scheme (and for that matter flooding risk situations more generally across catchments) have only slowly emerged as controversy has escalated. The pathfinder scheme trialled in East Anglia, England, for example, has examined a number of compensation measures for householders affected by coastal erosion. Under a Balance Sheets Approach the distributional impacts and 'local' impacts would have been diagnosed prior to the strategic policy switch, policy options would have been assessed and arguably more effective ameliorative measures would have been in place.

In the Balance Sheets Approach, three types of complementary assessments (balance sheets) are envisaged to try to give some guidelines for steering a reasonably objective course through these 'contested' policy contexts (see Fig. 2.8):

- Economic (monetary) CBA using a conventional economic efficiency criterion (macro UK economy efficiency), but augmented with a distributional analysis of impacts and possible equity weighting;
- Regional and local financial impacts and policy analysis, covering impacts like local unemployment, loss of community identity and related financial multiplier effects which often raise issues of compensation; and
- Trade-off analysis (non-monetary) better suited to dealing with collective or shared values across wider society such as, for example, intrinsic value in biodiversity, cultural services value etc.

The analytical sequence of the Balance Sheets Approach would typically begin with an economic cost-benefit scoping analysis and then proceed to include the other balance sheets depending on the issue and context under scrutiny. The aim would not be to aggregate the results of each balance sheet, but to present the policy process with the set of findings in as transparent a way as possible.

Given the range of data that relates to the marine environment and related socio-economic activities, there is a pressing need to agree broad categories of data which can illuminate the economic, social and environmental dimensions of environmental change in the marine context. The Balance Sheets Approach aims to achieve this by separating out, in the first instance, economic data and analysis. So in the first column of Fig. 2.8 economic data is covered and is guided by the criterion of macro-economic efficiency and informed by market-based data, willingness to pay (WTP) data and cost data (including second best data such as GVA, etc. – see Chap. 6). A key link to the second column in Fig. 2.8 is provided at the bottom of the first column when the issue of the distribution of costs and benefits is raised, i.e. who gains and who losses from any change. The second column of Fig. 2.8 now expands on the sort of data and issues that are best classified as social effects with a spatial boundary (local to regional) condition imposed on the analysis. The final column continues the social analysis but now encompasses values and impacts that are often expressed at the national scale with a variety of underlying ethical criteria. Clearly the columns overlap, but the aim is to give some logical sequence to a decision support method(s) and processes which are trying to scope and analyse real world (often 'wicked') economic and socio-political issues.

In ideal circumstances, the framework of action to deliver sustainable management needs to fulfil a set of tenets covering all facets of decision making and the identification of defendable sustainable development measures, especially in 'wicked' policy contexts (Elliott 2011, and references therein). These indicate that our actions are required to be environmentally or ecologically sustainable, economically viable, technologically feasible, socially desirable or tolerable, administratively achievable, legally permissible and politically expedient. These seven tenets (Elliott 2011) have been augmented by a further three tenets: ethically defensible (morally desirable), culturally inclusive and effectively communicable (Elliott 2013). This is a formidable list of requirements and pragmatism rather than a futile search for meta-ethical perfection is the recommended course of action under AM.

The final column's information also contains a reminder to set the proceeding analysis in an overall systems context, with due regard for threshold effects and the overarching goal of sustainable development. But following this guidance almost inevitable means trade-off choices and therefore winners and losers. The exact combination of decision criteria and support tools that are relevant will depend on the prevailing and expected policy context and the type of trade-off. The heavy, extensive and on-going utilisation of coastal and marine resources ensures that management decisions will be contested by competing interests. The goal of a return to good (pristine) conditions (Hering et al. 2010) is also unlikely to prove practicable, and so the DSS and social dialogue has to focus on the future and feasible future environmental system states.

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