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Enabling a Natural Capital Approach: Guidance

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What this Guidance is for

This Guidance is intended for those who are looking to learn more about natural capital and environmental valuation and need practical guidance. It forms part of a suite of Defra resources collectively called "Enabling a Natural Capital Approach" (ENCA). Other ENCA resources are referenced throughout the text.

1. An Introduction to natural capital

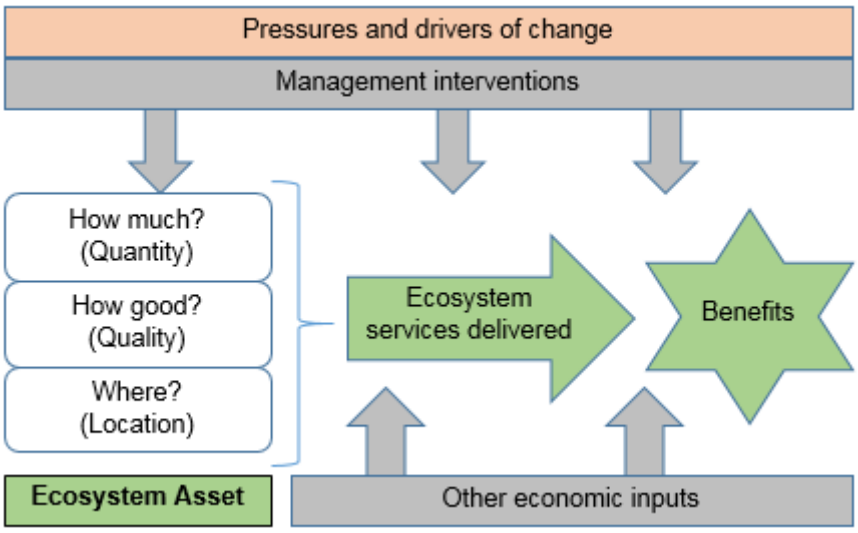
1.1 What is natural capital?

The natural capital framework demonstrates how elements within our natural world contribute to achieving the outcomes we seek as individuals and society more generally. According to HM Treasury's Green Book: Appraisal and Evaluation in Central Government:

> "Natural capital includes certain stocks of the elements of nature that have value to society, such as forests, fisheries, rivers, biodiversity, land and minerals. Natural capital includes both the living and non-living aspects of ecosystems. Stocks of natural capital provide flows of environmental or 'ecosystem' services over time. These services, often in combination with other forms of capital (human, produced and social) produce a wide range of benefits. These include use values that involve interaction with the resource and which can have a market value (minerals, timber, freshwater) or non-market value (such as outdoor recreation, landscape amenity). They also include non-use values, such as the value people place on the existence of particular habitats or species." (p.45)

At its simplest, a natural capital approach is about thinking of nature as an asset, or set of assets that benefit people. The ability of natural capital assets to provide goods and services is determined by their quality, quantity and location. These in turn can be affected by background pressures, management practices and drivers of demand. For some services, additional inputs are required in order to realise benefits. In other cases, the benefit follows directly from the service without further capital or human inputs (Figure 1).

Figure 1 - The Natural Capital Framework (source: Natural England)



1.2 Why take a natural capital approach?

Understanding nature as an asset which provides flows of services to deliver benefits provides us with a framework to manage it well to deliver for society's needs. Decision makers can more easily consider how investment in environmental assets contributes to wider societal aims and trade-offs which affect the quality or quality of assets. The framework also helps to better understand how policies can have unintended effects on the environment and result in environmental externalities.

In particular, a natural capital approach supports decision making as it:

- provides a common framework to bring together scientific economic and social evidence and analysis for a particular subject or place
- significantly reduces the risk of the value of the natural environment (whether monetised or not) being ignored in decision-making
- enables a more comprehensive cost-benefit analysis and risk assessment
- facilitates a more innovative approach to identifying policy solutions
- recognises the spatial variation of environmental issues
- helps to identify priorities for investment
- provides a basis for systematic accounting over time

"Natural Capital" has become a standard analytical approach to thinking about nature, building on the ecosystem approach which was prominent at the time of the UK National Ecosystem Assessment (2011). Natural capital as a concept has gained traction and permanence because it offers a balanced focus on natural assets in ecological terms (their quantity, condition and sustainability) and the social and economic benefits that derive from those assets. It also enables different disciplines to adopt a shared framework and understanding in both research and practical initiatives. However, it is recognised that "natural capital" as a conceptual approach and language may not resonate with all groups or be relevant for all purposes. In particular, other ways of understanding and valuing nature can cut across the distinctions and categories of natural capital. It is also recognised that a natural capital approach does not always require monetary valuation (see Section 2).

1.3 When to assess natural capital

Every case is specific to its own context. The Green Book Natural Capital Screening questions should identify whether further investigation is needed. If so, a 4-Step assessment method is recommended in the Green Book and detailed in Section 3 of this Guidance. If the focus is on biodiversity within the context of a specific site, the Defra Biodiversity Metric would be an appropriate tool (see ENCA Featured Tools).

The principles of natural capital are not just for policymakers and the public sector. Businesses of all kinds must make numerous decisions that can affect, or are affected by, the health and state of natural capital. These relationships can be complex and not always obvious. A natural capital approach can help to analyse what is at stake and translate this in to relevant information for decision-making. ENCA Case Studies include a number of business-related case studies.

A natural capital or ecosystems approach re-frames nature positively as an asset that can support a range of social and economic outcomes, rather than simply as a constraint on or a victim of development. In this way it differs from Environmental Impact Assessments and Strategic Environmental Assessments which traditionally focus on adverse environmental impacts of a project or programme. A natural capital approach is not confined to legal obligations, but can provide a more strategic basis for how the natural environment can be integrated with and deliver wider objectives.[1]

In addition to specific proposals, organisations may wish to understand what natural capital they are responsible for. At local level, this should be based on a systematic spatial mapping of land covers and the quantity, quality, condition and location of these assets or parcels of land, together with pressures and risks. The spatial scope will depend upon the type of organisation (such as local authority, utility, corporation, charity). See Section 5 of this document which introduces key approaches and tools that are relevant to taking a natural capital approach at a local level. Section 4 gives guidance on the more formal exercise of natural capital accounting, which accounts for both asset condition and the flow of benefits from a defined set of natural assets. Examples are included in ENCA Case Studies.

1.4 How to conceptualise natural capital

Natural capital stocks, or assets, can be conceptualised in different ways. A practical approach to thinking about natural assets comes from UK National Ecosystem Assessment which captures the diversity of the UK's ecology, geology and climate in eight "Broad habitat types" (Table 1). Each of these in principle represents a distinctive spatial area which can be combined like a jigsaw puzzle. These broad habitats provide the structure for the UK Natural Capital Accounts and for Natural England's Natural Capital Indicators.

In a policy context, it may be appropriate to broaden the definition of natural capital further to include all natural elements (such as atmosphere and climate) whether based on ecosystems or not. For appraisal and accounting purposes, however, it makes sense to define natural capital according to broad habitats. This enables a distinction to be made between negative externalities that are mediated, but not caused, by the natural

[1] For further discussion, see the UK National Ecosystem Assessment Follow-On, Embedding an Ecosystem Services Framework in appraisal: Key barriers and enablers (Work Package 9)

environment (such as air pollution, noise and climate change), and ecosystem services that are “supplied” by natural capital.

Table 1 - UK Broad Habitat Types (taken from the National Ecosystem Assessment)

Broad Habitat type	Summary Description
Urban	Urban areas cover just under 7% of the UK’s land area. They are home to 8 out of 10 people, often living at extremely high population densities. Urban green space is scarce but heavily used. Depending upon how urban extent is defined, it can include land covers associated with other broad habitats, in particular woodland, farmland and freshwater.
Enclosed Farmland	The most extensive form of land use in the UK, comprising arable, horticultural land and improved grassland as well as associated boundary features such as hedgerows. It accounts for around 40% of land area and supplies the majority of the UK's food. As well as playing a crucial role in provisioning services, Enclosed Farmland is also of great cultural significance and is a major determinant of landscape in much of lowland UK. Note that land in other habitat categories will also involve farming.
Mountains, Moors and Heathland	Comprises upland heath, montane habitats and associated wetlands; rainfall-fed blanket bog in upland environments; and lowland habitats dominated by heather and gorse. Mountains, moorlands and heaths are the source of around 70% of the UK’s drinking water, support livestock farming, hold an estimated 40% of UK soil carbon, and include some of the country’s most iconic landscapes. They cover 18% of the UK land area.
Freshwater	Freshwaters include open waters, wetlands and floodplains. Freshwater habitats are a major source of water for a wide range of uses and are important for recreation, including angling, boating and other water sports, and in hazard (notably flood) regulation.
Woodland	Includes managed plantations as well as ancient, semi-natural woodlands. Woodlands cover 12% of the UK’s land area, making the country one of the least wooded in Europe. Much of the woodland estate is managed as a source of timber, but woodlands are increasingly valued for their delivery of other ecosystem services, particularly recreation and carbon storage.
Coastal Margins	Coastal Margins, comprising sand dunes, machair, saltmarsh, shingle, sea cliffs and coastal lagoons, cover just 0.6% of the UK’s land area. Culturally, Coastal Margins are of immense significance. These areas are also important in coastal defences, sediment transport and as nursery grounds for fish, and livestock grazing on saltmarsh grasslands.
Marine	Marine habitats of the UK cover more than three and a half times the land area. They are highly variable, comprising a very wide range of sub-habitats. Inshore marine habitats are of great cultural importance, offering many opportunities for tourism and recreation. Offshore habitats support fisheries and provide a range of regulating services.

Semi-natural Grassland	Semi-natural grasslands are all grasslands unimproved for agricultural purposes. They once covered a large proportion of the UK's land area, largely the result of low-intensity traditional farming. The extent of semi-natural grasslands is now extremely reduced.

An alternative approach which recognises the ecological complexity of natural capital is set out by the Natural Capital Committee (Table 2)

Table 2 - Natural asset typology by the Natural Capital Committee

Natural asset type	Description
Species	All living organisms including plants, animals, fungi and micro-organisms; the product of ongoing evolutionary processes
Ecological Communities	A group of actually or potentially interacting species living in the same physical environment, for example wildlife habitats
Soils	The combination of weathered minerals, organic materials, and living organisms and the interactions between these
Freshwaters	Freshwater bodies (rivers, lakes, ponds and ground-waters) and wetlands. This includes water, sediments, living organisms and the interactions between these
Land	The physical surface of the Earth and space for human activity. This includes the various landforms and processes which shape these (weathering and erosion)
Atmosphere	The layer of gases surrounding Earth including oxygen, carbon dioxide and nitrogen used by all living organisms, and the processes which give rise to climate and weather
Minerals	Naturally occurring, non-living substances with a specific chemical composition formed by geologic processes
Sub-soil assets	Other non-living substances in the Earth's crust including rocks and aggregates as well as non-mineral substances such as fossil fuels
Oceans	Saline bodies of water that occupy the majority of the Earth's surface. This includes water, sediments, living organisms and the interactions between these
Coasts	The transitional zone between land and oceans. This includes water, sediments, living organisms and the interactions between these

The NCC's ecological categories are not mutually exclusive, so there is some overlap between them. They tend to represent spheres of policy intervention.

1.5 Biodiversity within the natural capital framework

Biodiversity is 'the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part' (Convention on Biological Diversity). In other words, biodiversity includes diversity within species populations (genetic variation); the number of species, and the diversity of ecosystems. Biodiversity can be thought of as a core component of natural capital with multiple effects on social and economic welfare. Biodiversity:

- is core to the ecological condition and quality of ecosystems that support the services provided to people
- directly benefits people through species existence, through nature-based solutions, and by enriching other benefits (like nature-based recreation)
- underpins the resilience of ecosystems to shocks and can provide insurance value

Because of these multiple roles, its value can be overlooked even in natural capital assessments. Some economic valuation of biodiversity is possible, but is unlikely to fully capture its range of benefits. This is why it is important not only to consider ecosystem services but the assets that enable these services. Biodiversity is represented in the Natural Capital Committee's typology as "species" and "ecological communities" but it underpins, to varying degrees, the benefits provided by the eight broad habitat types.

Policy will impact biodiversity if it is likely to cause the following types of changes:

- gains or losses in the variety of species
- gains or losses in variety and abundance within species
- gains or losses in the amount of space for ecosystems and habitats
- gains or losses in the physical connectedness between ecosystems and habitats
- environmental changes within ecosystems and habitats

Section 5 explains how the concept of biodiversity net gain relates to natural capital in a development context.

1.6 Services and benefits from natural capital assets

Services from natural capital assets

By understanding nature as an asset, it is possible to define the diverse "flows" of services those assets provide. To facilitate understanding and analysis, various attempts have been made since the Millennium Ecosystem Assessment to categorise and classify these

services.[2] The tabs in the ENCA Services Databook each focus upon a specific type of environmental effect or category (Table 3).

Provisioning, regulating, and cultural services are typically classified as "final" ecosystem services – they directly contribute to society's welfare.

Table 3 - Services provided by natural capital

Databook category	Description	Examples
Provisioning Services	Tangible outputs that can be obtained from ecosystems that meet human needs	Food, timber, water supply, crops
Abiotic flows of natural capital	Flows which are not dependent upon functioning ecosystems	Minerals, oil & gas; solar, wind and tidal power
Regulating services	Ecological processes that regulate and reduce pollution and other adverse effects	Air filtration, water regulation, noise mitigation
Cultural Services	Environmental settings that enable cultural interaction and activity	Settings for recreation, education, tourism
Aggregated/ bundled services	In practice the benefits provided by nature are not easily reducible to specific ecosystem services, or can reflect a bundle of cultural or regulating services. There can be overlap with these categories.	Amenity, biodiversity, landscape, water quality, non-use values

Another category of ecosystem services is "supporting services". These do not produce outputs for final consumption or production, but are essential for the functioning of provisioning, regulating and cultural services, which do provide outputs. Examples include soil formation and pollination.[3] This distinction is made to avoid the double counting of services. Supporting services are not included as their effect is already captured within the other Databook categories, including the bundled categories.

[2] The Common International Classification of Ecosystem Services (CICES) attempts to standardise understanding and definitions of ecosystem services.

[3] Ecosystem accounting distinguishes between "supporting services" which arise within the same ecosystem habitat (for example, soil formation on farmland), and "intermediate services" which are supplied by one habitat (for example, pollinators from semi-natural grassland) and used as an input by another habitat (provisioning services of farmland).

Alongside ecosystem services, it is important to include negative environmental effects that are typically caused by human activity (as externalities) and / or cause damage to society. These include air pollution, noise, soil degradation, invasive species, greenhouse gas emissions and flood damage. These negative environmental effects are an important category, because they have both a direct effect on welfare (for example, exhaust fumes harming the health of pedestrians) and also an indirect effect by affecting the condition of natural capital (for example, water pollution affecting recreational benefits) or increasing the importance of regulating services.

Benefits from natural capital assets

The quantity of these services will often depend heavily upon their local and spatial context, in the same way that the value of many produced assets and market goods (such as retail outlets and residential property) will be heavily influenced by their location. This makes it a challenge to generalise values for them.

Benefits are in theory distinct from services, since they relate to the consumption and welfare of individuals or the use in economic production. It is changes in these benefits which are the focus of valuation in appraisal. Several services can provide the same kind of benefit (such as different regulating services improving health), or be implicitly captured in the broad definition of a benefit (for example, improved water quality, amenity).

Table 4 shows the difference between the type of ecosystem service or environmental effect and the final welfare effect to be valued. It also indicates that welfare effects can be positive where natural capital is enhanced or negative environmental effects reduced. Welfare effects can be negative where natural capital is lost or negative environmental effects increased.

Annex 1 provides a more detailed overview of each of the categories and the final welfare effects.

Table 4 - Welfare effects of environmental categories

Databook Category	Example	Final welfare effects to be valued
Provisioning Services	Food, timber, water supply, crops	Production of final goods
Abiotic flows of natural capital	Minerals, oil & gas; solar, wind and tidal power	Production of final goods
Regulating services	Air filtration, water regulation, noise mitigation	Cost savings, reduced damage costs, health benefits, etc.

Databook Category	Example	Final welfare effects to be valued
Cultural Services	Settings for recreation, education, tourism	Recreation benefits, education benefits, producer surplus, health benefits etc.
Aggregated / bundled services	Amenity, biodiversity, landscape, water quality, non-use values	Various use and non-use benefits. In some cases, there may be trade-offs between different types of benefit.
Negative environmental effects	Air pollution, noise, flood damage, soil degradation, GHG emissions	Health costs, damage costs, output losses etc.

Typically, each broad habitat type will be associated with multiple ecosystem services and benefits. So a natural capital approach needs to consider a wide range of effects (many of which will have no market value) and different types of land cover. Services associated with one broad habitat type can also be affected by changes in other habitats (for example, changes in agricultural practices on farmland will affect freshwaters). The ENCA Services Databook and ENCA Assets Databook identify which services and benefits are relevant for each broad habitat type, so that users can prioritise what to focus on.

1.7 Different ways of taking a natural capital approach

There is no one natural capital method or model. Natural capital is a widely-owned agenda that has given rise to numerous research and analytical initiatives, models, tools and methods. Typically such initiatives are subject to testing and ongoing development. The UK National Ecosystem Assessment (2011 and 2014) helped to focus some of this academic work and supported standardisation. Building on the UK National Ecosystem Assessment, the work of the Office for National Statistics to develop natural capital accounts with Defra is providing a new standardised approach to measuring natural capital at a national level. However, this is not yet comprehensive and it does not eliminate the need for other types of models and approaches, depending upon the object in question.

For private sector organisations, the Natural Capital Protocol has been developed as an internationally standardized decision making framework that enables organizations to identify, measure and value their direct and indirect impacts and dependencies on natural capital. It also brings together a wide range of tools that may be relevant to businesses following the framework. It has many similar themes to this Guidance. The Protocol is very clear that it is only a framework, and does not seek to create or promote specific tools or methodologies. Further guidance on using tools can be found in Section 5.

Although there is a clear conceptual framework, “taking a natural capital approach” in practice involves a range of considerations and can take a variety of forms (Table 5). For examples of the range of applications, see ENCA Case Studies.

Table 5 - Natural capital approaches

“Taking a natural capital approach” can mean many or all of …	
Assessing baseline levels of natural capital	This is a logical first step in any natural capital approach: “What are our natural assets?” It can involve a systematic baseline assessment of the extent, condition and benefits of natural assets (Section 5), often at a landscape or regional scale, and is the basis for natural capital accounting approaches (Section 4). Such assessments can identify needs, priorities for action and further investigation.
Considering nature as one of the main forms of capital	Accounting and assessment approaches undertaken by companies or communities may wish to take a broad view of assets and societal wealth, which may involve human, manufactured, social and financial capital. Natural capital is clearly part of this holistic picture of wealth.
Using nature to identify new solutions to needs	The range of benefits provided by ecosystem services affects other domains such as health and well-being, productivity, resilience and education. A natural capital approach avoids a silo focus on individual sectors or issues and so can identify new solutions to problems in other domains. See Section 3.2 and Section 5.5.
A focus on assets and sustainability	Accounting for natural assets can ensure that the effects of many investment decisions that affect the stocks of natural capital are kept in view. Methods of measuring and valuing changes of individual decisions (such as biodiversity net gain metrics) are necessary to follow through on strategic commitments to improving the overall condition of the environment.
Understanding the science of ecosystem services	An understanding of biological and physical changes in natural assets can aid in the associated economic valuation. For example, understanding the impacts of a woodland creation and carbon sequestration project can help transfer their value into monetary terms. This exercise may be done as part of a more comprehensive baseline assessment or accounting exercise.
A rigorous approach to monetising benefits, and who benefits	A natural capital approach will highlight the range of services and benefits provided by an asset or an intervention, and which groups benefit (for example, businesses, local residents, users, global beneficiaries). This can help to identify new sources of investment and funding. Over time, many service values are likely to increase in real terms, and these should be factored in to appraisal and accounting approaches.

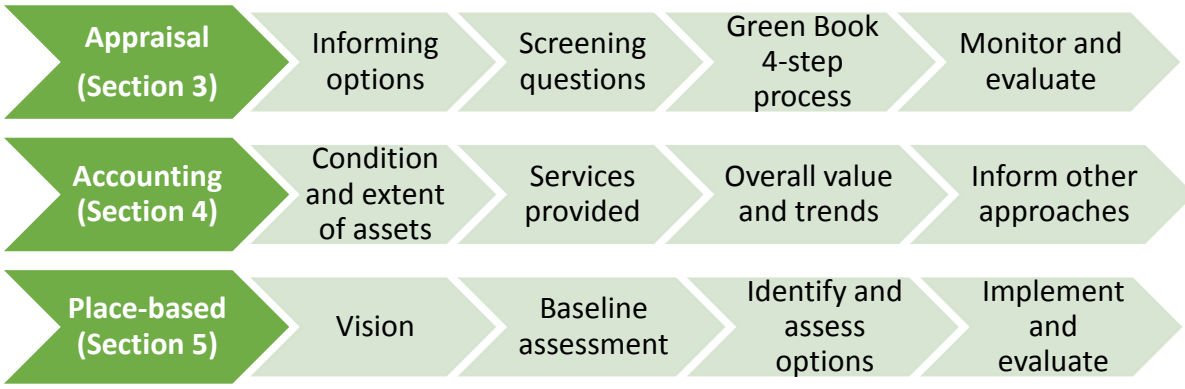
Consideration of geographical variation	Bio-physical environmental effects will often vary according to species, climate, soil type, and so on. Valuation effects of these are also likely to vary spatially, reflecting population patterns or existing provision. Mapping opportunities for enhancing ecosystem service provision can be an important part of a local natural capital plan.
Place-making	In the context of development and regeneration, natural capital forms an integral part of the infrastructure that underpins successful and liveable places. In this context, natural capital is known as "Green Infrastructure". Place-making is another example of systems-based thinking that natural capital promotes. See Section 5.3 for more detail.
Appropriate use of emerging tools	Extensive practitioner and academic interest in natural capital has led to the emergence of various tools which can facilitate consideration of the above effects. Care needs to be taken if appropriate tools are to be used in an appropriate way. See Section 5.

Some or all of these considerations will overlap depending upon the particular application. For convenience, this guidance is structured around three broad overlapping spheres of application of natural capital:

- incorporating natural capital into policy or project appraisal (Section 3)
- natural capital accounting (Section 4)
- place-based implementation of natural capital principles (Section 5)

Each of these involves, in principle a staged approach, summarised in Figure 2 and detailed in Sections 3 to 5. Common to all these is potential for economic valuation of the environment, which is covered first in Section 2.

Figure 2 Different spheres of natural capital approach



2. Economic valuation of the environment

2.1 What is economic valuation?

Economic valuation is one way in which to understand how much something is worth to people or society, typically by looking at the choices people make.[4] It is the attempt to estimate the welfare to society of the supply of, or changes in, environmental goods, services and qualities in monetary terms.

In many cases economic value is expressed and measured through market prices for goods and services which reflect the interplay of supply and demand. Provisioning services tend to be valued in this way. Many environmental services and effects are not typically traded in markets, because of their public good or externality characteristics (Section 3). These non-market values are harder to identify than market values, but observing forgone opportunities or people's willingness to spend resources on securing them can uncover their value.

Total Economic Value

Total Economic Value is a framework developed to characterise why and how individuals value the benefits received from the environment. Economic value can take different forms:

Use Value includes direct use and indirect use value. Direct use values occur where individuals make actual or planned use of an ecosystem service. Consumptive use value refers to the use of resources extracted from the ecosystem (for example, food, timber). Non-consumptive use is the use of the services without extracting any elements from the ecosystem (such as recreation and landscape amenity). Indirect use values occur where individuals benefit from ecosystem services supported by an asset rather than by directly using it. These tend to be the regulating and supporting services (for example, flood regulation, pollution filtering) and also various cultural services (for example, viewing nature programmes on television).

Option value is the value that people place on having the option to use a resource or asset in the future even if they are not current users. An example would be a national park where people who have no specific intention to visit it may still be willing to pay something in order to keep that option open in the future. Option value can also be thought of as a form

[4] This section draws on E. Ozdemiroglu and R. Hailes (eds.), Demystifying Economic Valuation (2016), produced by the interdisciplinary and Research Council funded Valuing Nature Programme. It offers an accessible introduction on economic valuation to non-specialists.

of insurance, such as a wide species mix in a particular habitat: as conditions change, different species may fulfil key ecological roles.

Non-use Value derives from the knowledge that the natural environment is maintained. It can be based on three different motives: (a) bequest motives where individuals attach value from the fact that the ecosystem resource will be passed on to future generations (just as they have benefited from inheriting from previous generations, such as ancient woodland); (b) altruistic motives where individuals value the availability of the ecosystem resource to others in the current generation (such as beaches in a distant part of the country); (c) valuing the existence of habitats or species for themselves irrespective of any actual or planned use of it, for example by making legacies to conservation charities; or donations for an endangered species that will never be observed.

Economic valuation of nature reflects the benefits that people derive from the natural environment ("what nature does for us"). It cannot be used to assess the preferences of non-humans nor any intrinsic value of nature.[5] So economic values are subjective, reflecting human preferences which can be driven by the interplay of ethics, culture, incomes, tradition and technology. Although values are subjective, they are often measured through objective data, and based on biophysical changes and metrics, such as tonnes or visits.

Economic valuation evidence can be accessed via the ENCA Services Databook and ENCA Assets Databook. See also Section 6 .

How are environmental effects valued?

Conceptually, the economic value of a positive change in the natural environment is typically measured by what individuals are willing to pay to secure this benefit. By contrast, the economic value of a negative change is measured by what individuals are willing to pay to avoid such a cost. There are different ways to estimate economic value depending on which effect or service we want to estimate. Valuation methods can be broadly divided between "revealed preference" "stated preference" and cost-based approaches. Annex 2 details the various methods. Knowing these methods and their advantages and limitations can help you make better use of existing evidence. This is also important if you are commissioning primary valuation research (see section 2.10).

[5] Many people, who hold non-use values in the economic sense, understand nature to be valuable beyond our individual relationship with it, or the benefits anyone gets from it. Such philosophical and religious perspectives lie outside economic valuation which is necessarily reductionist and based on individual subjective preferences. For a discussion of the intergovernmental IPBES approach to diverse perspectives of nature's value, see https://www.ipbes.net/diverse-values-valuation.

Are there standard environmental values?

Generic or standard values, with uncertainty ranges, do exist for certain environmental effects, such as greenhouse gas emissions, air pollution and noise pollution. For many other environmental benefits and losses, valuation estimates will tend to differ according to the characteristics, condition and extent of the asset or effect in question, its location and availability of substitutes. Furthermore, different methodologies in different times and places, using different datasets, have produced different estimates, and some methodologies are at an early stage. To make the evidence base tractable, the ENCA Services and Assets Databooks are selective in the studies that are included but this does not mean that studies or approaches that are not cited (for example, because they were undertaken in very localised contexts) are not valid.

The UK natural capital accounts developed by ONS and Defra provide more standardised aggregate estimates of various ecosystem services based on accounting methods. These are reported in the Databooks. Very crude average values by broad habitat can be derived by dividing aggregated service values by total areas, but these would be very partial and may not capture the full welfare benefit of a service; service values are likely to vary widely as noted above. The accounts are currently of experimental status and are subject to revision.

2.2 Why put a value on the environment?

The risk of not valuing non-market environmental goods and services is that positive and negative environmental outcomes get ignored in decision-making, resulting in losses to welfare and wellbeing. Valuation of often “hidden” benefits can contribute to enabling decision-makers to understand the contribution that an ecosystem makes to an area, or determine whether an intervention is justified, or determine priorities. It can also clarify who the beneficiaries or losers might be.

Valuation can test, and sometimes challenge, pre-existing assumptions and judgements as to the value of a project, intervention or service. As a piece of objective if partial analysis, it can encourage deeper reflection on issues and outcomes that may otherwise be exaggerated or neglected. For this reason it may not always clearly support a conservationist approach. Where the costs of an intervention exceed the benefits, valuation can still facilitate debate as to whether there are other unmeasured benefits or considerations that might tip the balance in favour of environmental protection or enhancement.

Economic valuation of the environment is typically undertaken for one of two purposes:

Estimating the change in benefit or cost from an intervention or project

This is part of economic appraisal or cost-benefit analysis (see Section 3).[6] Here the focus is on how an intervention might affect the services provided by natural capital, and other environmental externalities. In some cases, it may be technically possible to value directly the effect of a marginal change on the stock value (for example, on fishery stocks).

Environmental valuation is often unavoidable even if not explicit. For example, if an authority chooses not to spend £2 million on a scheme to improve water quality it implies that the marginal improvement in water quality is worth less than £2 million, or at least less than the benefits achieved by spending that £2 million on another project. Had an explicit valuation been done, it may have found that the additional benefit might comfortably exceed the £2 million cost (or the benefits of an alternative project), in which case an efficiency or welfare gain has gone begging.

Providing an overall assessment of the value of a stock of assets

This is known as natural capital accounting (see Section 4). In terms of accounting, valuing a snapshot of natural capital (for example, the value of parks within a local authority area) may be expressed in annual flow terms (parks provide £ million services per year) or as capital asset value (the lifetime value of parks is ££ million). The set of services included in an asset value is likely to be limited because of data and methodological challenges.

Economic valuation can demonstrate the value of a natural capital asset, which may in turn generate support for a wider agenda of environmental improvement, or prompt a new dialogue with stakeholders. For example, a local authority may wish to understand the value of the services provided by its accessible green and natural spaces, with valuation used as a communication tool to the wider public and business. This accounting approach can in turn be updated periodically and so enable monitoring of aggregate value and an assessment of change over time.[7] It does not make sense to put an absolute value on something (i.e. nature) that we cannot live without. But it can still be valued in a limited way. For example, the national housing stock can be valued even though it makes no sense to imagine a society without housing. In a similar way, human capital is measured by the Office for National Statistics based on the flow of future earnings related to the education of the working population; but this “human capital” does not “put a value on human life” or reference its intrinsic value.[8]

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[6] Valuation of marginal changes in environmental benefits or costs can also inform economic instrument design or the estimation of financial liabilities.

[7] See also the Natural Capital Committee’s guidance on the uses of valuation which covers similar themes to those in this section.

[8] Even where appraisal techniques can estimate a value for fatalities prevented, these are based on observed trade-offs between money and risk (for example, riskier jobs commanding higher wages), rather than on an absolute value of human life.

2.3 Being clear on what value is measured

Economic valuations can be expressed in a variety of forms and metrics depending upon the type of use, context and data. These can be a source of confusion, so it is important to be clear what exactly is being measured in monetary terms, as well as to whom the values accrue.

Values can be positive (the value of ecosystem services), or negative (for example, degradation of natural capital; damage costs of pollution). The reduction of a negative impact is a benefit while the reduction of a positive service is a cost.

Values may be expressed in aggregate (for example £ million) which can relate to different spatial scales (for example: UK, England, Greater London). Alternatively, unit values are those expressed in relation to a particular physical metric, such as:

- pound per hectare
- pound per kilometre
- pound per cubic metre
- pound per household

Unit values may relate to average values (for example, dividing aggregate woodland values by the total number of hectares) or marginal values (what is the additional value of an extra hectare of woodland?). It is important to be clear what unit values represent and which is appropriate. Use of average values in cost benefit analysis may be misleading where the focus is on marginal changes.[9]

Values may be expressed as annual estimates (£ / per year) or as capitalised, "present value" estimates that reflect an expected flow over many years. It is important not to confuse the two, as they will be measuring different orders of magnitude.

Benefit values can be combined with measures of cost to provide absolute Net Present Values (NPV) or benefit-cost ratios (BCRs). BCRs can provide an intuitive summary of public value for money from an intervention (a BCR of 5 means that for every £1 spent, society benefits by £5).

Another key question is: whose values are measured? This may not always be obvious. Are those affected by a change, local, regional or the whole population? Are there socio-economic differences between beneficiary or affected groups? Beneficiaries may be households (as consumers, visitors or passive recipients), businesses (for example, where there are cost savings) or government or taxpayers (local or national). Further guidance is given in the ENCA Services Databook for individual effects.

[9] This may not matter if there is no material difference between average and marginal values. For example, the same value for avoided carbon emissions can be used to value one additional hectare of woodland planting or forestry across a region. However, there will be differences in physical flows of carbon sequestration between a new hectare of young woodland and the average physical flow of existing mature woodland.

2.4 Applying valuation evidence to new contexts – value transfer

Doing environmental valuation is not simply a matter of "finding a value". Rather, it is a careful process of applying pre-existing economic valuation evidence (either benefits or costs) to a new policy or appraisal context. This is called value transfer. It is a quicker and lower cost approach to generating economic valuation evidence when compared to commissioning a primary valuation study, and enables proportionate analysis in line with Green Book guidance. The key steps are:

1. Be clear on the purpose for the valuation and the decision context. What level of accuracy is required, is value transfer appropriate? The more accurate results need to be, the more effort is required.

2. Identify the population affected by the intervention. Who are the users? Could non-users be affected?

3. What benefit is changing that is to be valued? Describe this in qualitative and quantitative terms.

4. Identify the most appropriate valuation evidence / study. There may often be several options. Where apparently inconsistent values are provided, the user should investigate the relevant studies further to make a judgement about what is appropriate to use. Even similar studies differ in their scope and object of what is being valued. They will use different datasets and possibly locations, and have been produced at different times.

5. Convert the study year prices (which are indicated in the ENCA Services Databook) into relevant base year prices (such as 2018 or 2019) using the GDP Deflator (also included in the Databook).

6. Conduct sensitivity analysis based on any ranges given, alternative estimates from studies not chosen, or other uncertain variables (such as changes in quantity). This is extremely important, especially where there is uncertainty regarding the appropriateness or robustness of the favoured valuation estimates.

See more detailed value transfer guidance, including full technical report and non-technical summaries.

2.5 Projecting values into the future

If you are doing cost-benefit analysis or accounting, you will need to project values over a future appraisal period or accounting life-span. The Green Book suggests 10 years as a standard period for many typical appraisals but up to 60 years where significant assets are concerned, and longer if there are very long-term costs and benefits. For ecosystem services, the UK Natural Capital Accounts project future service flows over 100 years, so

as to reflect the longevity of renewable natural assets.[10] These are discounted to a present value using Green Book declining discount rates.[11]

The real value of many ecosystem services is likely to increase over time, reflecting:

- increased relative scarcity of natural capital assets
- rising demand for the benefits that are provided by natural capital (for example health)
- increasing numbers of users of ecosystem services through population growth
- climate change trends (reflected for example, in a growing role for urban cooling services and natural flood management, or a rising trend in non-traded carbon prices)

Per unit increases in real values typically take the form of a 2% annual uplift, which is the standard assumption for future health values (including air quality and noise impacts).[12] For some regulating services, one factor offsetting these trends is a downward trend in the hazard that is being mitigated. This may apply for example, to declining levels of background air pollution over time. See ENCA Services Databook for specific guidance by individual service or effect.

2.6 Challenges and limitations of using economic valuation

If you use economic valuation of the environment, be aware of its technical and inherent limitations.

Virtually all non-market valuation evidence is subject to uncertainty. In many cases, this is because the scientific effects are uncertain, or based on modelling (for example, regulating services such as air pollution removal or flood regulation). Uncertainties and methodological limitations should be presented transparently. Making use of appropriate uncertainty ranges and providing appropriate caveats and undertaking sensitivity analysis and quality assurance is therefore essential. See value transfer guidelines above.

Environmental valuation will also typically be partial, where multiple effects are expected and valuation evidence is not available. Where partially monetised benefits of an intervention to enhance nature clearly exceed the costs this may not be an issue; it simply means the benefit-cost ratio represents a lower bound of value for money. It becomes an issue where ecosystem services would be lost from an intervention (for example, through

[10] See ONS / Defra Principles of Natural Capital Accounting, Principle 8.3. This notes that assumptions of asset life for buildings and transport range from 59-100 years or more. With Green Book declining discount rates, an accounting life of 100 years captures around 92% of the discounted value of an infinite lifespan.

[11] For an academic review of the social discount rate and intergenerational rates, see M. Freeman, B. Groom and M. Spackman (2018), *Social Discount Rates for Cost-Benefit Analysis: A Report for HM Treasury*

[12] This 2% annual uplift is conceptually and mathematically equivalent to reducing the discount rate by 2% for health and life values as set out in HM Treasury Green Book, p. 103. This is also adopted in the UK Natural Capital Accounts.

infrastructure) and valuation of those losses are exceeded by the non-environmental benefits of the intervention. This could lead to perverse outcomes if in reality there would be greater environmental loss than that which had been monetised. Even a partial valuation can however inform discussion as to the trade-offs between monetised and non-monetised effects.

The values of many regulating and cultural services will vary from place to place. This reflects the proximity of beneficiary populations as well as spatial variations in biophysical processes. Use of average or national values in localised contexts may therefore be misleading, in the same way that the average price of a three bedroom house will vary significantly depending upon its location in the UK. Values will also depend upon the distribution of income, as is the case with all market values. It is important to understand to whom the benefits as valued accrue. See the Green Book for guidance on undertaking distributional analysis.

Presentation and positioning of results is critical. If not presented carefully, economic values can be a source of confusion or even misuse. Although monetised non-market values are real welfare values, they may not imply financial savings or benefits, or increases in economic activity. At a local level, there may be more interest in accounting measures of gross value added and employment than in economic welfare.

Finally, economic valuation assumes we know what is to be valued. However in the case of complex ecosystems, ecological processes and their interdependencies are not fully understood, and outcomes from loss or enhancement are uncertain. In these cases, valuation of individual ecosystem services will be inadequate. Reasoned or evidence-based arguments for action or inaction may be more appropriate.

Taking account of other valuation perspectives

Bear in mind that “valuing” nature is not solely the domain of economic valuation, and that “nature” is a broader concept than “natural capital”. The focus on costs / benefits rather than ethics / meaning is a limitation of valuation that needs to be acknowledged and positioned within a wider decision-making context. So consider how qualitative social and cultural assessments of environmental change can complement economic valuation to inform the policy cycle.

The UK National Ecosystem Assessment “Balance Sheet” approach” offers a means of collating, analysing and presenting this diverse data and evidence within the policy process.[13] The three stages reflect increasing complexity of the environmental context, and consist of:

1. conventional strategic analysis - such as cost-benefit analysis and environmental impact analysis, with increased focus on distributional and equity issues

[13] See Section 1.4.6 of the UK National Ecosystem Assessment Follow-On Synthesis Report (2014) for more detail on the Balance Sheet approach.

2. regional and local impact analysis – with greater spatial and socio-economic information on winners and losers, and potential compensation measures
3. analytical support to address "contested" policy context issues - where different groups hold different ethical positions, attitudes to risk, or cultural heritages

Relevant evidence can be drawn from multi-criteria decision analysis methods and group-based deliberative methods which encourage and inform discussion and debate among relevant participants. The Green Book advises that Multi-Criteria Decision Analysis is a technique that can be employed, in certain circumstances, to consider un-monetised trade-offs, and rank options. These considerations are particularly important for place-based natural capital approaches (see Section 5) involving economic appraisal and valuation.

The UK National Ecosystem Assessment also sets out guidance on how to characterise and assess the shared values provided by natural capital that are not easily reducible to conventional economic values.[14] These deliberative, analytical, interpretive and psychometric techniques include:

- in-depth discussion groups and citizens' juries
- participatory mapping and modelling
- group-based monetary valuation
- story-telling and media analysis
- historical analysis
- subjective wellbeing indicators

These are particularly important if the cultural services provided by natural assets are to be fully and fairly assessed. Incorporating qualitative and quantitative assessments into the decision-making and appraisal process ensures that economic valuation evidence represents a "witness" rather than "judge".[15]

2.7 Assessing how robust valuation evidence should be

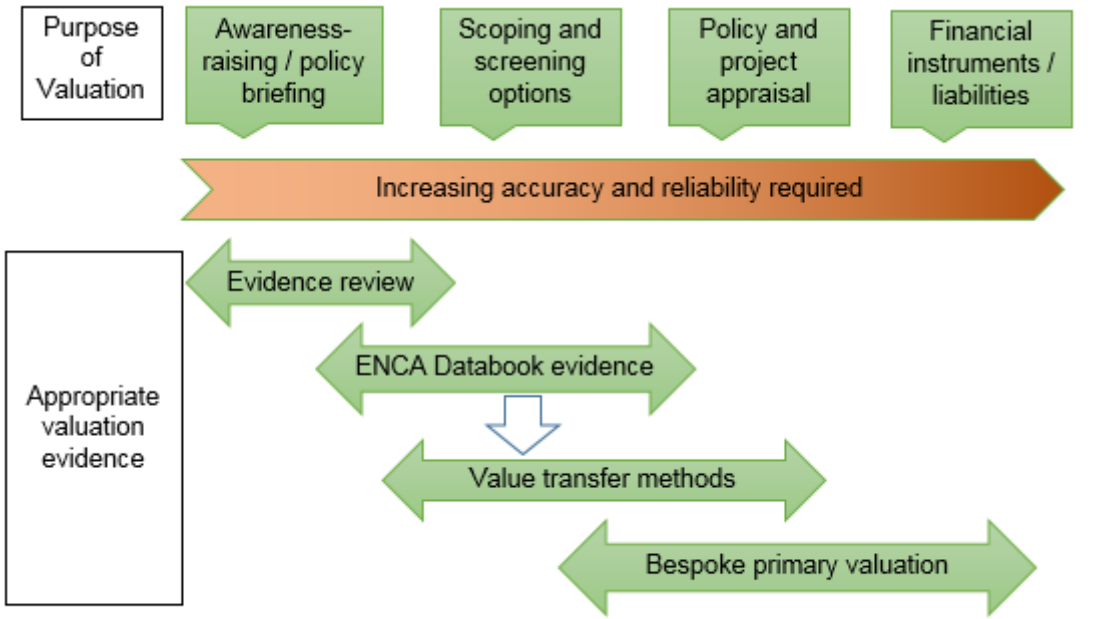
Valuation evidence for some environmental effects is well established and consistent. For others the evidence is fair but incomplete or inconsistent. Some evidence is subject to high uncertainty and requires further research. A high-level robustness rating is given for each category included in the ENCA Services Databook.

[14] For a full treatment, see UK National Ecosystem Assessment Follow-On, Shared, Plural and Cultural Values: A Handbook for Decision Makers (2014) which provides practical information and examples of when and how shared values other than economic values can be taken into account in decision making.

[15] For insight on the views of the general public on economic valuation of the environment, see Naturally Speaking … A Public Dialogue on the UK National Ecosystem Assessment (2015). This identified both the strengths of monetary valuation (for example, its communicating power) and its limitations (particularly in more complex decision-making contexts).

The desired accuracy of economic valuation will depend upon the purpose for which it is used. These uses range from awareness-raising and context-setting (what values are at stake? what is the order of magnitude?) and accounting (how do assets compare and change over time?), through to scoping and screening (are values likely to be significant?), detailed appraisal (value for money and ranking priorities), and finally detailed design of economic instruments (marginal valuation, or cost-recovery approaches) and liability calculation (the most precise). At each stage, the required robustness and reliability of the evidence becomes greater. ENCA Databook evidence and associated evidence reviews will be sufficient for initial briefing and scoping. Further value transfer would be needed in appraisal. Bespoke primary valuation would be necessary where there are significant appraisal or legal needs (Figure 3).

Figure 3 - How robust should valuation evidence be? [16]



Based on Eftec (2015)

Values taken from the ENCA Services Databook can be used as indicative values to give a sense of how significant certain impacts might be, and to identify key sensitivities where more accurate valuation evidence is needed. Not all effects will be equally material, or equally influential on the result (for example, because they do not vary across options). Often the relative change in a value will be more important than the absolute level of the estimate, for example in assessing trends in value over time (as in National Accounts), or understanding differences in valuation between project options, services or habitats.

The more localised the effect, the more robust or specific a value will need to be. The robustness of economic valuation will also depend upon what other complementary forms of valuation and assessment are made, and how sensitive outcomes are to key variables.

[16] Figure based on Eftec, Environmental Valuation Look-up Tool: User Guide (2015), for Defra.

Where proposed interventions are novel, large scale or high-risk, then economic valuation becomes more problematic and the role of expert assessment and stakeholder engagement that much more important.

2.8 Creating new valuation evidence – primary valuation

Where no relevant valuation study exists and the cost-benefit analysis is seen to depend significantly on the magnitude of the environmental effects, undertaking a primary valuation study may be justified. Primary valuation is where new evidence is created to fill an evidence gap, involving data collection and / or modelling. This may take two forms:

- development of new biophysical and valuation models
- conducting survey-based stated preference studies

Primary valuation studies can be costly and time consuming so it should be undertaken only when it is proportionate and appropriate. Prior scoping and a literature review may be required to ensure that the primary valuation is addressing the right priorities and is technically feasible.

Guidelines for good practice in designing primary valuation studies are included alongside Defra's value transfer guidance (as Annex 2). This includes guidance on how to address challenges and biases in stated preference studies. If you are commissioning a primary valuation study, you may wish to reference these guidelines for potential bidders.

Quality assurance is a key consideration in primary valuation studies. This involves independent expert peer review of proposed survey design and econometric modelling specifications, together with piloting and testing of surveys, and careful scrutiny and sense-checking of emerging results. Application of Defra's Value Transfer Protocol for primary valuation studies can ensure that primary valuation results are presented transparently and in a way which facilitates subsequent use in value transfer contexts.

2.9 Quality assurance

If you are using economic valuation, provide adequate assurance that addresses the following questions[17]:

Is the level of effort proportionate to the purpose?

Have appropriate sources of evidence been used?

Have value transfer principles been adopted?

[17] General government guidance on analytical quality assurance and addressing analytical uncertainty is included in the Aqua Book.

Where values are partial, is this made explicit? And is qualitative evidence presented to complement partial valuation evidence?

Are risks and uncertainties clearly set out? Has appropriate sensitivity analysis been undertaken on the key assumptions that might affect results? Is a worst-case scenario included?

How much scope is there for challenge based on the methods, evidence and assumptions used?

Where multiple services or benefits are included, is there any double-counting of the same benefit?

Have spatial considerations and variations been taken into account?

Are quantitative and qualitative assessment that underpins valuation estimates presented clearly?

Are distributional effects relevant and considered? Is it clear who the beneficiaries or losers are?

Where relevant, is valuation based on, and integrated with assessment of effects on natural assets (as set out in the Green Book 4-step process)?

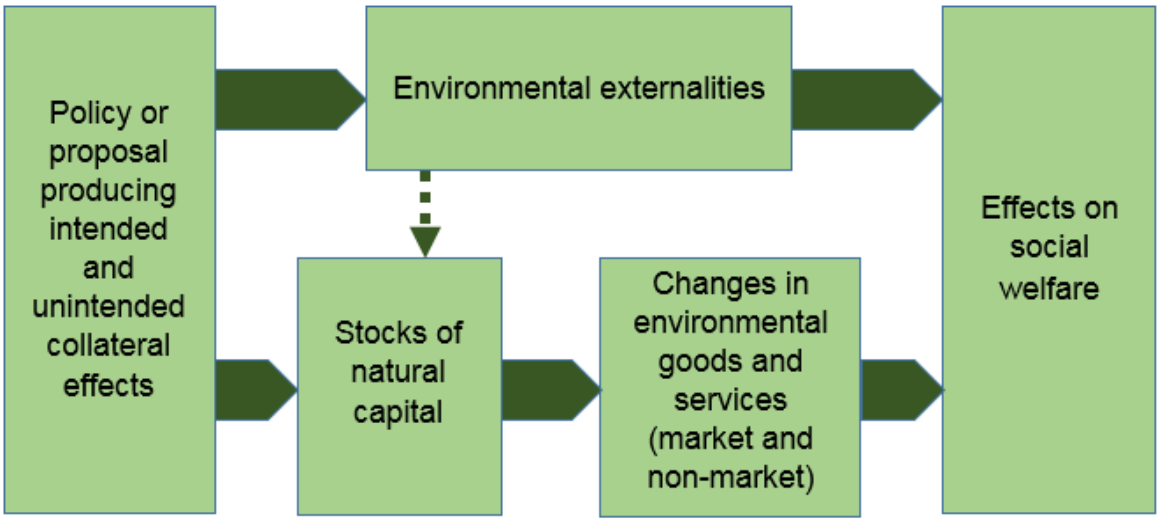
Is a consistent year adopted as a price basis for different valuations?

3. Including natural capital in policy or project appraisal

This section builds on and is consistent with existing guidance on natural capital within HM Treasury Green Book.[18] It provides guidance on how natural capital thinking can be applied at each stage of the appraisal cycle (rationale for intervention, generating options, assessing impacts, and monitoring and evaluation).

Figure 4, taken from HM Treasury's Green Book, provides a simple representation of how policies or proposals may affect stocks of natural capital directly and in turn affect ecosystem services. It also shows the effect of "traditional" environmental externalities (described in ENCA as "negative environmental effects") on welfare. In reality, environmental externalities such as air and water pollution will also adversely affect natural capital stocks (dashed arrow inserted), so there are indirect effects on welfare via degradation of natural capital. Natural capital thus enables a more comprehensive understanding of the state and role of the environment in assessing policy, one that considers both the stocks of natural capital and the benefits that it provides.

Figure 4 – Green Book impact pathway framework



3.1 Rationale for policy intervention in natural capital

Where natural capital is monitored and accounted for, it is likely to identify issues and potential areas for new policy intervention. Natural capital is associated with several types of market failure which can justify government intervention.

[18] In particular paragraphs 6.45 – 6.51 ("Assessing and valuing effects on the natural environment") and Annex A2, paragraphs 2-29 ("Non-market valuation: Environmental and natural capital").

Public Goods - Many services provided by natural assets are not supplied through markets. For example, climate regulation and the ability of vegetation to absorb air pollution benefits whole populations. An upland area may provide ecosystem services to a population downstream in terms of water filtration and alleviation of flood risk. Urban parks have public good features despite being potentially excludable (gates can be locked and an entrance fee charged) and potentially congested. Open access natural assets such as fisheries and recreational sites can be subject to degradation where there are biological or biophysical limits and this too would be an economically inefficient outcome that may warrant government intervention.

Externalities - Many decisions relating to natural assets are associated with negative externalities. These tend to result in inefficiently high levels of resource depletion, pollution and damage. For example, pollution of watercourses, biodiversity loss, excessive land-use conversion, depletion of peat bogs. Where natural assets have been depleted beyond economic efficient levels, it makes economic sense to enhance and restore those assets.

Imperfect or asymmetric information – This can take various forms, for example where users or consumers of natural resources are not aware that their use or consumption can lead to degradation or depletion of natural resources (for example, use of palm oil, or poorly managed timber forest, trade in ivory products). Loss of biodiversity and endangered species in part reflects a disconnect between ecological reality and the activities and choices of final consumers. Solutions include better public information, certification and designation, creation of new markets, and, in extreme cases, prohibition on use or trade.

Poor understanding of how the natural environment works or how an intervention might damage nature can itself lead to inefficient decisions. The natural capital approach itself aims to improve information and understanding available to decision-makers so as to make better informed decisions.

Equity considerations – Equity across income groups but also between generations, provides additional justification for government intervention in the natural environment. For example, Natural England's visitor survey data indicates inequality in access and enjoyment of the natural environment, and that this is linked with unequal health outcomes. Within urban areas, less well-off groups tend to have poorer access to green space. At the same time, differential engagement with nature across demographic groups partly reflects empirical variations in individual and cultural preferences.[19]

3.2 Natural capital options to meet policy goals

Where enhancing or protecting natural capital is the object of policy or spending (for example, a programme of peatland restoration or tree planting, or new environmental land

[19] See for example, modelling of MENE data done as part of the development of the Green Book endorsed Outdoor Recreation Valuation Tool. Technical Report, pp. 39-42.

management schemes), the standard Green Book approach to identifying a range of options applies.

However, natural capital is not simply an object of policy, or a constraint on other policies. Because it benefits people and society, it does not simply belong to one sector (the "environment"). Rather it can, as stated in the Green Book, "suggest additional options to meet policy goals" (Table 6).

Table 6 – How nature-based approaches can support policy goals

Policy area / goal	How natural capital can contribute
Supporting physical health	• Nature-based recreation (various habitats) • Settings for walking and cycling routes • Removal of air pollution
Improving mental health	• Nature-based recreation for different ages • Mitigation of road traffic noise • Incorporating views of greenspace from schools, hospitals, workplaces • Nature volunteering and green prescriptions
Productivity and industry	• Nature-based tourism and outdoor leisure • Greenspace amenity in workplaces • Cooling effect of urban green and blue space during extreme temperatures (mitigating output loss)
Housing and place-making	• Provision of recreation and amenity • Contribution to sense of place • Mitigation of pollution pressures from new development • Streamlined approaches to compensating for biodiversity loss
Reducing greenhouse gas emissions	• Woodland creation • Saltmarsh creation • Peatland restoration
Climate resilience	• Natural flood management approaches • Sustainable urban drainage schemes • Cooling effect of vegetation in cities • Habitat restoration

Improving education	• Settings for outdoor learning • Support for ecological knowledge and qualifications
Social cohesion and loneliness	• Good quality green space provides opportunities for community events and interaction • Safer more welcoming outdoor environments • Nature-based volunteering
Cultural heritage	• Many aspects of cultural heritage (for example, historic landscapes, ancient monuments), are underpinning or surrounded by natural capital

3.3 Screening for effects on natural capital

Use the Green Book screening questions (paragraph 6.50) to consider the possibility of unintended consequences on, or missed opportunities for, natural capital. A slightly more detailed version with guidance is given in Table 7. The questions relate to different aspects of the natural capital framework. It is important to give adequate thought to each question, particularly effects which may not be immediate or direct. Any initial reasoning can be briefly noted along with the answer. Only say "No" if you have sufficient reason or evidence for doing so.

Table 7- Screening for natural capital impacts

Screening question and guidance	yes / possibly / no
Is the proposal likely to have any effects on the use or management of land in the UK? Land is the basis for natural assets and the various "broad habitats" that occupy land: woodland, moorland, enclosed farmland, urban, semi-natural grassland, coastal margins. Any proposal that potentially affects management or use of the land, including through changing incentives, will be in scope.	
Is the proposal likely to affect the atmosphere in any way? This primarily relates to potential effects, positive or negative, on air quality or its composition – including GHG emissions. It also includes effects on levels of noise or tranquillity.	

Is the proposal likely to affect any type of inland, coastal or marine water body? The water cycle cuts across natural assets, and includes non-tidal rivers, lakes, ponds, wetlands, floodplains as well as coastal estuaries and the marine environment. It also includes groundwater where water is stored beneath or within soil and rocks.	
Is the proposal likely to have any effect on wildlife? Wildlife is an indicator of biodiversity, as too is wild vegetation. Biodiversity is core to natural capital and can also be a final cultural service in its own right. Wildlife can be affected not only by direct changes to protected sites but also by disrupting or creating connections between sites.	
Is the proposal likely to have a significant effect on the supply of raw materials from natural sources? A proposal may not affect land or natural assets directly, but it may have strong indirect effects through significant changes to a certain type of raw material which comes directly from a natural source, particularly non-renewable sources. This may have implications both for the sustainable supply of that material or for the wider environment in which it is extracted.	
Is the proposal likely to affect opportunities for outdoor recreation? Nature-based outdoor recreation is a major source of non-market value provided by the environment. This includes very high values provided by green spaces in and close to urban areas for example, urban and country parks; local woodlands; riverside paths.	
Is further assessment required?	
If further assessment is required, note here whether on this first initial assessment, the likely overall effect for natural capital of the proposal is positive, negative or mixed	

Further assessment (see below) is recommended if: (a) you have answered “yes” to at least one question; or (b) you have answered “possibly” to at least two questions. It is also useful to summarise whether, in response to the questions, the initial expectation of effects are likely to be positive or negative, recognising that many factors will not be known.

Follow existing guidance where changes in specific negative externalities are identified or expected (such as effects on air pollution, noise or greenhouse gas emissions). However, such effects are often linked with other effects on natural capital, so it is important all effects are accounted for as stated in the Green Book. All relevant guidance is signposted

in the ENCA Services Databook. Where appropriate and proportionate, significant overseas environmental effects should also be identified and assessed.

3.4 Assessment of natural capital effects: the Green Book 4–Step approach

If the screening questions suggest potential environment effects, you should adopt an impact pathway approach to assessment. This approach assesses how a proposal may affect natural capital assets, what this means for welfare, and whether effects can be valued.. To do this in a rounded and considered way, Section A2 of the Green Book, recommends a structured 4-Step process.[20] Each step is described below with additional guidance. An Excel template provided is useful for gathering relevant information for each step in a simple structured way. You can also use the template to develop comparative outline assessments for a proposed programme of different measures.

Step 1 – Understand the environmental context to the proposal

The first step of assessing effects on natural capital is to understand the relevant natural systems that may be affected or contribute to outcomes, and the environmental context of the proposal. This also helps to establish a baseline against which effects can be assessed. The typology of "broad habitats" set out in Section 1 offers an entry point into understanding natural capital and the benefits that nature provides. The 8 broad habitats are:

- urban
- enclosed farmland
- mountains, moors and heath
- freshwater
- woodland
- coastal margins
- marine
- semi-natural grassland

Each of these categories has its own tab in the ENCA Assets Databook bringing together key sources of physical and valuation evidence. The ENCA Services Databook does the same for different categories of environmental effect or benefit.

Describe the proposed measure. Natural capital assessments work best where there are well-specified and quantified measures with respect to scale and location (for example

[20] The screening questions in Table 7 and the Four-Step assessment tool were originally developed to enable a preliminary assessment of over 90 possible carbon reduction measures included in the Clean Growth Strategy of 2017. For further information on this application, see ENCA Case Studies.

hectares of coastal habitat affected). Identify the scale, location, outputs and spatial reach of the intervention.

Step 2 – Consider how natural assets might be affected

An understanding of physical, spatial or biological changes in the location, extent, condition and diversity of natural assets is the starting point of the appraisal and associated economic valuation. For example, understanding the impacts of a woodland creation and carbon sequestration project. This should be easier once you have a good understanding of which broad habitats are affected in Step 1. For this step of the assessment, you will:

- identify which types of natural asset (such as land use, atmosphere, water bodies, natural resources, species, wildlife habitats and soils – see Table 2) might specifically be affected
- consider the spatial nature and scale of effects - these may be localised or widespread, discrete or diffuse
- decide whether these effects represent risks or opportunities - are they modest or significant?
- consider the likely timeframe of effects - are they immediate, short term (within a year or two), or longer term?

This step facilitates the assessment of relevant welfare effects in Step 3. It also informs on the physical sustainability of natural stocks, which should be clearly reported in an appraisal. Non-marginal effects such as reaching ecological tipping points might lead to dramatic or irreversible loss in the asset under consideration. This would result in a loss of environmental services and welfare.

Step 3 – Consider the welfare implications

How will changes to assets (identified in Step 2) affect benefits provided to the society by natural capital? The Green Book states: “Understanding natural capital provides a framework for improved appraisal of a range of environmental effects alongside potentially harmful externalities such as air pollution, noise, waste and greenhouse gas emissions”. So multiple impacts may need to be measured and valued. For example, the costs of a proposal that would destroy woodland could include the loss of the following: timber value, carbon sequestration, recreational value, biodiversity and “non-use” values, as well as direct externalities such as noise and air quality. Care should be taken to avoid double-counting where impacts overlap. The ENCA Services Databook provides more specific guidance on this.

The range of potential impacts include direct or indirect effects on the various services and benefits set out in Section 1. Of these, regulating and cultural services and the bundled categories typically lack market values. A first step is to assess:

- Who might be affected? How many?
- Can the change in service be quantified in physical terms?

Environmental effects and associated values are often geographically specific. The recreational value of new or destroyed woodlands, publicly accessible green space or changes in air quality may be greater in or near densely populated locations than more remote areas. Recreational values may be greater where there are fewer alternative sites.

The ENCA Services Databook can be reviewed for relevant valuation evidence and sources appropriate for identified effects. See Section 3 of this Guidance for further detail on undertaking economic valuation.

Effects and factors that cannot be monetised should be treated as recommended in Annex A2 of the Green Book. In some cases it may be possible to identify trade-offs between different costs and non-monetised impacts of different options.

Step 4 – Consider uncertainties and optimise outcomes

Environmental effects may be uncertain. Therefore, consideration needs to be given to quantifying these uncertainties as risks that must be costed and managed, so that they can be minimised, mitigated or where possible avoided. This will include consideration of:

- the critical factors that could have a major influence on how natural assets and services are affected by the measure (which may require further investigation)
- arrangements for monitoring these critical factors in order to manage risks and optimise outcomes
- mitigating measures so that risks to natural assets can be minimised and benefits or opportunities maximised

Finally, effects on the sustainable use of natural assets should also be reported, drawing on Step 2. In addition to the marginal valuation of a loss in services, the degradation of a renewable asset should be assessed, such as the exploitation of a fishery or a loss in condition of the underlying biodiversity. Non-marginal effects such as reaching ecological tipping points might lead to dramatic or irreversible loss in the asset under consideration. This would result in a loss of environmental services and welfare. Cumulative effects of multiple investment decisions upon the underpinning stocks of natural capital should also be considered.

Completing these 4 steps may reveal knowledge and evidence gaps that may warrant further research and assessment. It is important when presenting results of natural capital assessment in an appraisal to be clear how far economic valuation captures the full range of relevant effects (see also Section 2.7).

3.5 Monitoring and evaluation

Step 4 of the detailed assessment can directly inform plans for monitoring and evaluation. The environmental risks, opportunities, costs and benefits identified at the appraisal stage should figure as part of process evaluation (whether the policy is being effectively implemented) and impact evaluation (Are outcomes being realised? Have there been unintended consequences?). Monetisation of effects based on actual changes can be useful although a full understanding of outcomes and impacts will also typically require other metrics and qualitative evidence.

The emphasis on data within a natural capital approach may enhance evaluation, by helping to ensure monitoring and data collection are given greater priority, so data may then be available to evaluation which would not otherwise have been the case. Where natural capital accounts or natural capital indicator frameworks are established, there is a ready dataset for monitoring change on assets, services and benefits. Care needs to be taken in order to interpret changes in accounts and the factors that are driving those changes.

The emphasis within natural capital on geographical variation is an important consideration in monitoring and evaluation, although this will depend on available data.

4. An introduction to natural capital accounting

Natural capital accounting is the attempt to bring a systematic, standardised and repeatable framework to assessing and monitoring natural capital and the services it provides, whether those services have a market value or not. In so doing, accounts can help to measure, value, monitor and communicate the state of natural assets within a given territory, bringing together a coherent body of physical and monetary information on the asset itself and the flows of services that it supplies.[21] It can be done at national, regional, local or organisational level.

Natural capital accounts record the physical state of assets and the volume of services. Ideally accounts should be based on spatially disaggregated data where possible, although this is challenging particularly at larger scales. Economic valuation is therefore just one part of natural capital accounting and it also has particular features which can differentiate it from other forms of economic valuation.

A key distinction in accounting systems is that of stocks and flows, which reflects the distinction in the natural capital framework between assets and services. In national accounting, a stock refers to the quantity or value of an asset at one point in time (or the end of an accounting period), and will cover concepts of extent, condition and wealth. A flow refers to the supply of services provided by the asset and used within an accounting period, usually a year.

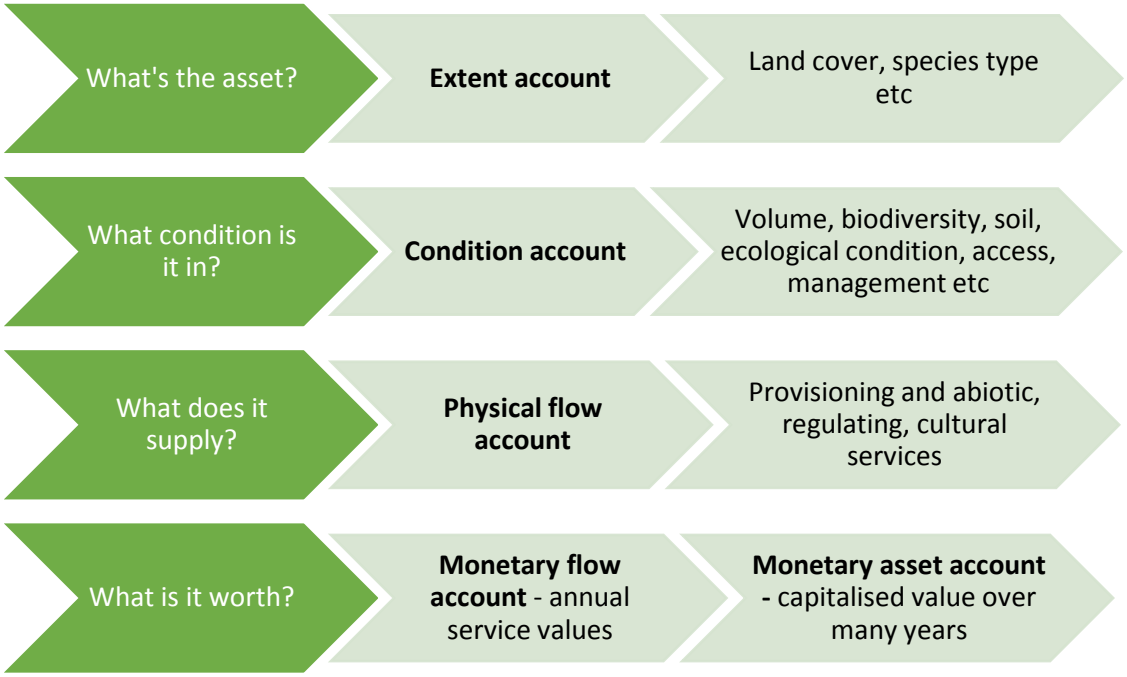
Accounting seeks to answer four key questions in an integrated and systematic way, through the production of inter-related accounts (Figure 5). For further guidance on the four types of accounts, see the Principles of Natural Capital Accounting produced by the Office for National Statistics and Defra.

Distinction from other types of assessment

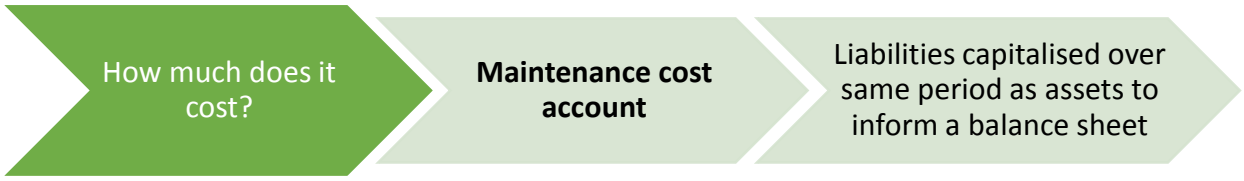
Natural capital accounting does not in the first instance seek to answer a specific policy question. It therefore differs from one-off studies which focus only on changes in flows such as cost-benefit analysis or one-off natural capital assessments that are not repeated.

[21] International discussions in this area focus on “ecosystem accounting”. Defra and ONS use the term “natural capital accounting” to include abiotic services, such as renewable energy and minerals, that depend on natural assets in addition to the three categories of ecosystem service.

Figure 5 - The scope of natural capital accounts



In addition, at corporate or city level, it is often appropriate to include a further component (see guidance on Corporate Natural Capital Accounting by the Natural Capital Committee):



At the same time, natural capital accounting is in its infancy and methodologies and conventions are under ongoing development and discussion internationally. The Office for National Statistics and Defra have been developing initial accounts and practical methodologies for the UK since 2013. The distinctive features of accounting are thus continuing to take shape, with some features more critical than others (Table 8)

Table 8 - Essential and desirable features of natural capital accounting

Feature	Essential	Desirable
Accounts for annual flows in physical and monetary terms	**x**	
Time-series for service flows	**x**	
Focus is on assessing the contribution of the ecosystem	**x**	
Excludes negative impacts caused by human activity	**x**	

Feature	Essential	Desirable
Consistent conceptual approach across all services	**x**	
Draws on range of information sources	**x**	
Transparent and repeatable methods	**x**	
Committed to improve over time	**x**	
Spatially disaggregated		**x**
Estimates an asset value in monetary terms		**x**
Includes cost information		**x**
Benefits from effective user and expert engagement		**x**
Integrated into management reporting processes		**x**

Table 9 summarises the key conceptual differences between accounting for natural capital and economic appraisal.

Table 9 - Comparison of accounting and appraisal

	Accounting for natural capital	Appraisal (Cost Benefit Analysis)
Scope and focus	Understanding the state of the current stock of assets and what they currently provide. Aims to be comprehensive.	A policy or spending intervention which will affect natural assets and the provision of services in some way.
Context and purpose	Tends to inform the strategic context. Ongoing and repeated. Provides basis for prioritisation	Tends to a more operational context – assessing specific priorities. Will be a one-off piece of analysis for a particular decision.

	Accounting for natural capital	Appraisal (Cost Benefit Analysis)
Which aspects of the environment are valued?	Focused only on what nature provides – but aims to be comprehensive. Valuation focuses on the ecosystem service (for example, the contribution of the ecosystem to farming, rather than the output of farming itself). Negative externalities caused by human activity should be accounted for separately as they are not produced by the ecosystem.	Will only focus on aspects of the natural environment that are materially affected by an intervention. This may include negative environmental externalities. Appraisal will focus on the final economic impact, which may include non-environmental inputs and outputs.
Forward or backward-looking?	Backward looking. Used to monitor trends. Asset values are however based on projections of ecosystem services into the future	Forward looking. The outcomes of an appraisal and its decision should in principle be captured in subsequent accounting.
Valuation concept	Based on the concept of a transaction or exchange having taken place between the ecosystem and the user. Potentially welfare values can also be accounted for where appropriate. Accounts can only estimate a positive flow of services. Environmental pressures may be captured in the condition account.	Typically welfare values for non-market goods rather than imputed market values. These may be negative or positive values. In some cases, accounts and appraisal can make use of the same non-market values.
Type of value	Baseline, average values. These will tend to give relatively large magnitudes	Marginal values based on the change affected by an intervention.
Cost information	The core UK accounts do not include cost information. Production costs should not be included in service values. Sub-national and corporate accounts should typically include the costs of maintaining the services valued, so costs can be compared with benefits on a consistent basis.	An essential part of appraisal – these can include environmental as well as other types of costs

	Accounting for natural capital	Appraisal (Cost Benefit Analysis)
Role of Net Present Value and discounting	Net Present Value is used to value an asset. Future expected flows of services are discounted to a Present Value, which gives a monetary value of the asset. Strictly this is not "net".	Net Present Value used to summarise the balance of benefits and costs of an intervention or investment.

4.1 The benefits of natural capital accounting

A natural capital account provides a structured approach for integrating a range of information from disparate data sources about natural assets, their condition and the services they provide. At a local or regional level it can provide a solid basis for a natural capital plan (See Section 5). It can provide a strategic overview of the state and value of natural assets if not immediate answers to operational questions. In particular, accounts can:

- encourage balanced attention upon asset condition, current flow of services and expectations of future service flow
- highlight key trends over time (as accounts are repeated) and, therefore, priorities for investment
- enable clearer exposure of evidence gaps ("what we know least about") and the incentive to fill them through developing new measurement and valuation methods and data sources
- support systems-based thinking, identify new lines of inquiry linking previously disconnected spheres of operation or data, and support identification of priority areas of investment
- provide a means of monitoring outcomes of strategies to make better use of natural capital, and encourage greater accountability
- generate physical and monetary indicators, which may be derived directly from the accounts in combination with other socio-economic information
- facilitate accountability and transparency relating to the use and benefit and funding of public natural capital assets

Monetary valuation in natural capital accounts offers particular advantages. It can:

- provide a common metric through which services can be aggregated and compared within and across ecosystems, and at national level, can be compared and in time integrated with economic data in the National Accounts

- highlight the value of non-market ecosystem services, and what is driving that value (or lack of value). It can be helpful to understand the relative differences in value (and hence potential trade-offs) between different services
- demonstrate that natural assets are not simply a financial liability or a constraint, but offer real value to people and the economy (for every £1 spent, the asset generates a minimum of £x of benefit / service)
- clarify who benefits from ecosystem services and by how much, potentially generating discussion of developing new equitable mechanisms to fund nature;
- provide a base for scenario analysis, in which different forward projections of service flow can generate different estimates of net present value.

The value of an account is maximised if it is repeated, updated and developed over time, enabling further benefits such as:

- policy relevant indicators, linking data from different sources
- a basis for analysis and modelling, linking with the national accounts
- a better understanding of which different social groups benefit from natural capital.

Ongoing improvements in accounts increase their value to users as time series are developed, in turn raising awareness and interest in improving data collection and methods and filling gaps, leading to a virtuous circle (Figure 6).

Figure 6 - The virtuous circle of accounting

4.2 Developing an account in practice

Development of a serviceable and influential natural capital account at any scale will depend upon, or be enabled by a number of factors.

Start somewhere, but provide sufficient resources. Baseline studies are often a good starting point, but the key is having capacity to maintain and develop accounts.

Consistent methods and a clear and transparent framework provides a starting point based where necessary on pragmatic conventions and ONS / Defra Principles of Natural Capital Accounting. The “perfect should not be the enemy of the good”.

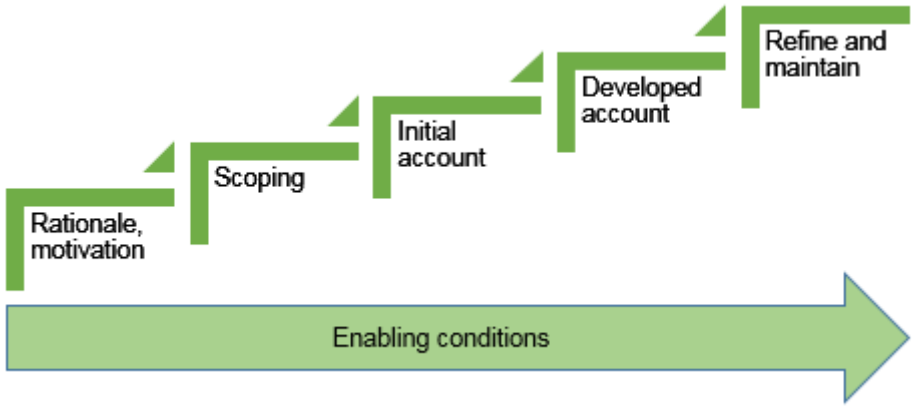
Compilers should be open to a wide range of existing and new sources of information.

Open up discussion with a wider community of institutions and users for engagement and feedback. Identify “early wins”; get potential users excited whilst retaining rigour and credibility, but be open about limitations and managing expectations.

It can be useful to think of the development of an account developing in stages (Figure 7):

1. Rationale – clear commitment, understanding uses and limitations of accounts.
2. Scoping – review evidence, conceptual issues, draw on ONS principles
3. Initial account – get feedback, identify gaps; badge as experimental
4. Developed account – after one or more iterations, including time series
5. Refine and maintain - ongoing commitment to improve and update; credibility increases as data points and experience grow.

Figure 7 - The stages in developing a natural capital account



4.3 Natural capital accounting at different spatial scales

There is considerable overlap between national, corporate and local approaches to natural capital accounting, as reflected by existing guidance and practice. There are also legitimate differences between these types of accounts, reflecting the different needs and scales involved. At the same time, methods and approaches can differ between different published accounts undertaken by different organisations, reflecting both the experimental

nature of natural capital accounting, including what is valued and how it is valued. Table 10 compares accounting at different spatial scales. The UK accounts are all referenced in the ENCA Assets Databook. Further examples of sub-national natural capital accounts can be found in ENCA Case Studies.

4.4 Use of economic valuation in natural capital accounting

In accounting, the focus is on how much of a service has been provided in a particular time period, so that annual changes and trends over time can be identified. So it attempts to assess the total baseline level ("supply") of a service rather than a marginal change in on economic welfare arising from some intervention. There are two types of valuation in natural capital accounting:

- valuing the actual flow of services
- valuing ecosystem assets

Valuing the actual flow of services

These will typically be based on flows of the physical service using physical metrics. Various valuation methods can be used. The aim is to identify and value the contribution of the ecosystem to the benefit. For provisioning and some cultural services, the ecosystem contribution will only form part of the benefit. For regulating services, there is typically no distinction between the value of the final benefit (for example, health benefits from air filtration) and the value of the ecosystem service (reduced exposure to air pollution from vegetation).

Valuing ecosystem assets

These are capital values which reflect an expected stream of future service flows in the same way that a house price, a company share or the transfer price of an elite footballer represent stock values. For the UK natural capital accounts, this asset value is based on projecting services over 100 years and discounting according to HM Treasury Green Book to a "net present value" i.e. capitalised value. The projection will reflect expected trends in the physical flow and trends in real value or price of that flow.

Table 10 - Accounting at different spatial scales

Scale	National	Corporate and public land-holding	Regional, local authority, site level
Guidance and standards provided by:	Office for National Statistics with Defra; the UN System of Economic Environmental Accounting. Based on conceptual architecture of the System of National Accounts	Natural Capital Committee (see Guidelines)	Draws on both National and Corporate guidance
Treatment of asset extent and condition	Broad habitats accounted for separately. Currently limited spatial disaggregation. Currently seven categories of asset condition each with a number of characteristics / indicators that are relevant to the range of services.	Extent will refer to one land manager's or land owner's assets. Typically combined into a single "Asset Register" of multiple land covers.	Typically combined into a single "Asset Register" of multiple land covers. Biophysical, economic and spatial data needs to be of much higher resolution than national accounting data.
Treatment of service flows and their valuation	Rigorous focus on valuing the service so as to ensure consistency across services, habitats and time. Valuation should imply a real or notional exchange between ecosystem and user – which may not be the same as a welfare value. This produces a supply-use table.	Typically a less strict definition of services (compared to national accounts) and a wider scope of benefits may be included. Values typically divided between benefits internal to the accounting organisation (marketed goods) and external benefits (non-marketed goods)	Typically a less strict definition of services is used and a wider scope of benefits may be included. Beneficiaries may be grouped for example, businesses, households, public sector.
Approach to asset accounting	Services typically projected over 100 years, and valued using present values. Maintenance costs are excluded.	Projection periods vary; present value of benefits often compared with maintenance costs to demonstrate net value.	

Scale	National	Corporate and public land-holding	Regional, local authority, site level
Examples	Aggregate UK accounts Scotland accounts UK Woodland UK Urban areas UK Farmland UK Freshwaters	Forest Enterprise England Natural England NCC pilots RSPB	Barnet Beam Valley Birmingham Greater London Authority Greater Manchester

Use of exchange values in accounting

Monetary valuation provides a common metric through which services can be aggregated and compared, and at national level comparisons made with the flows and stocks that are already included in the System of National Accounts (SNA). Importantly, the SNA does not seek to capture the total welfare value provided by goods and services, but rather accounts more pragmatically for the values of those services as or if traded (so-called "exchange value"). This makes practical sense. Housing, for example, can be ascribed an exchange value, based on aggregating the market value of all existing houses, or rental services. However, a total welfare value of housing makes less sense, since society cannot do without housing. The same principle can be applied to ecosystem goods and services.

For services that have no market value, the aim would be to "value the quantity of ecosystem services at market prices that would have occurred if the services had been freely traded and exchanged." (ONS / Defra Natural Capital Accounting Principles 6.6). This implies the need to impute an exchange value.[22]

Use of exchange values may appear less essential for natural capital accounting at corporate or local level, and welfare values are typically used where this is the obvious method. In such cases, however, there may not be consistency between the valuation of provisioning services valued at market rates and other non-market services which reflect the full welfare benefit (consumer surplus) to users.

Identifying exchange values for ecosystem services is conceptually challenging and the subject of ongoing discussions in the international accounting community. Resource rent

[22] Valuation principles for ecosystem accounts are an active area of discussion within the UN System of Environmental Economic Accounting revision process. The outcomes of this process will in due course be reflected in updates to the ONS / Defra Natural Capital Accounting Principles.

and production function approaches, avoided or replacement costs and hedonic approaches are generally favoured from the perspective of national accounting principles. For some services, exchange values are likely to be significantly smaller than welfare values (for example, for outdoor recreation or the physical health benefits that derive from it).

Additional guidance on the use of valuation for accounting is provided for individual services in the ENCA Services Databook.

4.5 Challenges and limitations

With natural capital accounting still in its infancy, there are a number of challenges and limitations, particularly around data and valuation.

The key data challenges include:

- the need for reliable measures of extent and condition for assets
- medium-term planning for data and research to support improvement / timeliness of the accounts (for example, land cover data)
- datasets that are partial or have insufficient spatial resolution to measure actual ecosystem services (such as reduction in flood risk)
- frequency of updating datasets, and a consistent time series in order to identify trends
- the lack of spatially disaggregated data at the necessary scale

For these reasons, it is important to be clear what an account does not include, and so leave space for wider considerations and values to inform deliberations around natural capital. However, even partial accounts with data gaps can still provide some powerful insights and catalyse new avenues of inquiry.

If you are looking to produce a natural capital account, you should be aware of the issues surrounding the valuation of ecosystem services and assets in accounting:

> The representation of natural capital in monetary accounts will only ever be partial. Many cultural services and in particular those that relate to future generations are difficult if not impossible to value.
>
> Valuation techniques are not often precise, yet accounts rely on “single point estimates”. So initial estimates should be seen as indicative, subject to uncertainty and revision. Transparency on method is key. It is important to understand that levels of uncertainty will not be the same for each service, and this needs to be communicated. Single point estimates are less of an issue than consistency of approach when the purpose of accounts is to compare values over time and across assets and services.

There is limited standardisation of environmental values for accounting, although guidance in ENCA and as provided by the ONS / Defra Natural Capital Accounting Principles is supporting more consistency. More consistent approaches to valuation, service definition and asset condition, and scope for flexibility, will be further supported by forthcoming guidance and standards in the UN System of Environmental Economic Accounting (SEEA).

More generally, natural assets are interrelated and complex, subject to biophysical uncertainties (flood regulation), spatial variations (recreation, air filtration), environmental limits and thresholds. Science is needed in order to understand these relationships and interpret the results.

Valuation needs to be considered alongside other biophysical information about the assets, particularly so that the purpose of accounting is not misunderstood as purely a matter of monetisation. The two should not be separate: for example, future service flows need to reflect both the current and expected future condition of an asset, although this relationship is often not fully understood.

Not all accounting values may be appropriate for use in cost-benefit analysis. Further guidance is provided in ENCA Services Databook.

Even a reasonably comprehensive set of natural capital accounts will face various limitations. They would not value the full range of environmental impacts and externalities imposed by human activities, but instead focus only on what nature provides (although some human pressures will appear in the condition account). It may be relevant to report on these separately, or to provide a more thematic analysis of what is happening (for example, relating agricultural activity to the natural capital of farmland and freshwater). Secondly, it may not be possible to capture an overall indicator of sustainability of natural capital, for instance because asset values reflect a range of other factors. Finally, accounts may be too broad-brush to inform spatially specific land management decisions regarding where to enhance natural capital. In this case more specific detailed appraisal would be required as set out in the Green Book.

In general it should be recognised that natural capital accounts, because of their limitations, should be seen as complementing other established forms of information, analysis and evidence.

5. Place-based natural capital approaches

5.1 Practical guidance on natural capital planning

Several practical guides have been developed to support a systematic natural capital approach or "plan" at a local or landscape scale. This is an evolving area that can involve elements of appraisal, accounting and valuation as set out in previous sections. An overarching guide is provided by the Natural Capital Committee (NCC) in its Natural Capital "How To Do It" Workbook". This sets out five stages to producing a generic "Natural Capital Plan". These principles are being adopted in various spatial and institutional contexts.[23]

1 – Set the vision

The first stage is being clear on the motivation. There are many circumstances in which individuals and groups might want to use a natural capital approach to protect and improve the environment. Often these might start from an overall goal describing what is to be achieved over time. Starting with a goal in mind can help to engage, inspire and gain the involvement and buy-in of local partners. Note that stakeholders may not be familiar with or comfortable with the language of "natural capital". Other terms, such as "green infrastructure" (see section below) may be better understood.

2 – Understand where you are starting from

A key challenge is getting stakeholders on the same page. The purpose of this stage is to ensure that basic information relevant to natural capital in the area being considered is gathered, documented, and synthesised, including:

- the baseline position of the various natural assets
- plans and activities already in place
- information about any other activities that could have a beneficial or adverse impact on the environment

3 – Build the evidence base

This stage requires measuring and analysing the natural assets within scope, identifying the ecosystem services and social benefits they provide, and assessing the condition of assets in relation to the benefits derived from them. This is a data-intensive and

[23] For example, planning for local natural capital has a dedicated role in informing the strategic growth potential of the Oxford - Cambridge Arc, beginning with baseline assessment and local stakeholder engagement. See ENCA Case Studies for a variety of other applications of local and regional natural capital approaches.

interdisciplinary task that may involve use of tools and be structured as a natural capital account for the area in question.

4 – Identify and assess options

This draws together the previous stages into the formulation of a plan of action, identifying a set of options that add up to more than the sum of their parts. This stage can involve appraisal (see Section 3), modelling, use of tools, scenario development and deliberative discussions in order to agree a preferred plan and options, and also consideration of potential innovative funding approaches.

5 – Implement and evaluate

This is about making the plan a reality, based on sound governance and project management principles. As the work develops and the plan is implemented on the ground there also needs to be an effective process for monitoring and evaluation (see Section 3.6).

Complementing the Natural Capital Committee's Workbook, earlier practical guides (based on the very similar "ecosystem approach") cover broadly similar steps but with different focuses and levels of detail.

The Ecosystem Approach Handbook by Natural England aims to help landscape scale partnerships benefit from the ecosystem approach. It builds on partnership projects that Natural England has supported in upland areas to help shape future land management in these areas. The focus is on people, processes and partnerships, drawing on experience of members of the Ecosystems Knowledge Network. The Handbook, like that of the NCC's, is structured around defining a partnership, understanding the place, developing a plan for change with integrated delivery and monitoring.

The Ecosystem Services Assessment Guide produced by ecologists in Natural England and the Environment Agency. It offers more technical guidance on how to assess likely ecosystem service outcomes across a range of contexts, including:

- development or management initiatives where there is a pre-determined approach, or set of potential approaches
- where novel options for place or scheme development are being explored
- assessment of the ecosystem service outcomes of schemes or projects already completed

5.2 How to make good use of natural capital "tools"

Natural capital approaches and plans as set out by the guidance above typically involve the use of tools. A "tool" is a generic term for a range of methods that users can interact with to provide tailored information and analysis. The diversity of natural capital assets,

land covers and ecosystem services means that no single tool can address every aspect. Through testing, use and time, some tools become more used and developed, others fall by the wayside. Note that the term “tools” can also be used loosely to refer to methodologies, approaches and resources that support decision-making. This can be a source of confusion.

Tools for assessing and exploring natural capital can be divided into three categories[24]:

- mapping natural capital stocks (habitat and land-use surveys; mapping ecological networks for wildlife; assessing the condition of ecosystems)
- quantifying ecosystem service flows (simple scoring tools; process-based and rule-based spatial modelling; monetary and non-monetary valuation)
- opportunity mapping (analysing ecosystem service supply and demand to look for gaps; opportunities to improve networks for wildlife and people; cost-effectiveness analysis)

The Ecosystem Knowledge Network’s “Tool Assessor” provides a consistent and detailed review of some of the leading models within the sphere of natural capital and land use. The focus is on helping practitioners manage the environment as an asset rather than purely for conservation. These and others are referenced within the ENCA Services Databook and Assets Databook in their relevant context (by broad habitat or ecosystem service), with guidance on their use.

Certain tools that are developed or supported by Government have a particular importance, and these can be found in ENCA Featured Tools, which provides summary information for each tool relating to who produced it, what it does, why it is useful and how it works in practice.

The proliferation of various “tools” or “toolkits”, although reflecting healthy innovation, can be a source of confusion to practitioners on the ground. Some general principles and questions can enable users to make use of the diversity of tools and avoid pitfalls:

Purpose - Be clear about the purpose in using a tool, and its relevance to the specific context. For example, is it to value a single ecosystem service for a parcel of land, or to inform a more strategic approach to assessing natural capital across a landscape? A combination of tools may be the most appropriate way forward.

Quality of evidence - How up to date is the tool? Is it based on evidence that may be several years out of date? Not all evidence is of equal quality, even within the same tool. Are there any subjective elements that may involve scope for bias? Who has quality assured / approved the tool?

[24] This classification and this section draws from the Final Report of a stakeholder workshop on natural capital tools convened by Defra.

Accessibility – are the results easy to interpret? Can they be intuitively communicated to decision-makers or stakeholders?

Limitations - Are you clear as to the evidence gaps and the assumptions in the tool? No tool is perfect, the issue is whether the evidence is good enough to inform a decision. Clarity on limitations can enable other approaches to complement the use of a specific tool.

Transparency - It is important for tools to be seen to be making decisions more rather than less transparent. There is a trade-off between ease of use and hidden complexity (the "black box") and natural capital necessarily is complex because of multiple ecosystem services and data requirements.

Evidence of use - Consider where the tool has been used before and in what context and by whom. Some tools are developed but fail to get embedded.

Comparing tools - It may make sense to test more than one tool on one scenario or project (such as a target catchment or newly developed neighbourhood) so as to allow comparison of what different tools can offer, their strengths and weaknesses.

5.3 Applying natural capital in urban and planning contexts

At local planning and urban scales, the understanding of nature as an interconnected set of assets that provide a range of benefits is more likely to use the language of "green infrastructure". Green infrastructure is formally defined in the National Planning Policy Framework *as 'A network of multi-functional greenspace, urban and rural, which is capable of delivering a wide range of environmental and quality of life benefits for local communities'*.[25] It includes:

- parks and gardens – urban parks, country and regional parks, formal gardens
- amenity greenspace – informal recreation spaces, housing greenspaces, domestic gardens, village greens, urban commons, other incidental space, green roofs
- natural and semi-natural urban greenspaces - woodland and scrub, grassland, heath or moor, wetlands, open and running water, wastelands and disturbed ground
- green and blue corridors – rivers and canals including their banks, road and rail corridors, cycling routes, pedestrian paths, and rights of way
- other – street trees, allotments, community gardens, city farms, vegetated sustainable drainage systems, green walls and roofs, cemeteries and churchyards

Through a natural capital lens, green infrastructure can be considered as a network of natural assets operating as a system encompassing the facilities and management

[25] Ministry of Housing Communities & Local Government, National Planning Policy Framework (2019), *Glossary,* p. 67.

needed to deliver a range of provisioning, regulating and cultural ecosystem services and other social benefits. A local natural capital account can help to clarify and measure the existing state of assets and the services that are provided. The amount, quality and location of green infrastructure will affect the benefits it provides, as well as who benefits. Good green infrastructure can be a significant driver of place-making, economic activity, climate resilience, and health and well-being, in new and existing neighbourhoods and settlements.

Defra is currently working with Natural England to develop a National Framework of Green Infrastructure Standards. Whilst there are some well established and emerging schemes and standards that make an important contribution to improving the planning, delivery and quality of green infrastructure, a national framework will provide common principles and metrics to enable local authorities, developers and communities to plan, design and maintain green infrastructure in an evidence-based, consistent and effective way.

Further guidance on the role of green infrastructure in a planning context is provided by the Ministry of Housing, Communities and Local Government.

Natural capital in relation to biodiversity net gain

In a land use development context, a natural capital approach is based on the concept of environmental "net gain", in particular residential or commercial development that achieves a measurable net improvement in the condition and quantity of natural habitats. This is the aim of the Biodiversity Metric. Building on this approach, a natural capital net gain approach would measure a wider range of ecosystem service benefits in addition to biodiversity net gain. As noted in Section 1.3, biodiversity is a core component of natural capital on which the range of services typically depends. Biodiversity is not seen as simply one service to be traded off amongst others. This is the focus of Natural England's Ecometric Tool (currently in development). Other natural capital approaches to development include application of the Natural Capital Planning Tool (developed by University of Birmingham) and the "Natural Capital Trust" concept developed by the West of England Nature Partnership. There are various applications of these tools in practice.

5.4 How natural capital can support local economic development

Investment in the quantity and quality of natural capital or green infrastructure can support local economic development and productivity in a wide range of ways suggested by the evidence base.

Publically accessible green space supports physical and mental health and social capital. Visits to recreation sites increase where pedestrian access is made easier, and

habitat is more diversified and water quality improved.[26] Siting green spaces near to workplaces supports the mental and physical health of workers.

Natural flood risk management and vegetated sustainable drainage systems improve resilience to extreme weather events. Trees and blue spaces cool extreme temperatures, allowing businesses to reduce productivity losses.

Carefully sited tree and woodland planting can improve air quality, reduce traffic noise and reduce hot temperatures, all with health and productivity benefits.

Green infrastructure can encourage more sustainable forms of travel, reducing carbon emissions and air pollution. Provision of publically accessible green and blue space supports physical exercise which has a range of health benefits.

Business opportunities arise from outdoor recreation and nature-based tourism. In turn, nature-based tourism and outdoor leisure directly depend upon the quality and condition of the natural assets that support them. The same is true in a less direct sense of regional and local branding.

New renewable energy sources can create new hubs of economic activity, although the implications for other natural assets would need to be considered.

Enhancement of green infrastructure can give places the opportunity to grow and support economies of agglomeration by managing risk and the capacity of the environment to cope, including through biodiversity net gain, provision of green space and nature-based enhancement of grey infrastructure.

These relationships between the economy and environment can be explored through the Local Environment and Economic Development (LEED) Toolkit designed for Local Enterprise Partnerships and local authorities.

5.5 Generating new income streams through a natural capital approach

Some of the benefits provided by natural capital have the potential to generate cost savings or commercial benefits which can in principle generate financial returns. This understanding has been growing over the last decade and it can help to identify new approaches to funding the protection and enhancement of those underlying assets.[27] These include:

- investments in sustainable enterprise models that directly benefit natural capital and biodiversity (even if they are not a core objective of the business)

[26] See for example the ORVal tool.

[27] For an introduction to the wider concept of, and definitions around, “green finance”, see E. Ozdemiroglu, Demystifying Green Finance (2019), Valuing Nature Paper.

- mitigation and offsetting mechanisms focused upon particular habitats or species
- direct payments based on ecosystem service outcomes from natural interventions ("payments for ecosystem services").

Payments for ecosystem service schemes are feasible where specific groups of beneficiaries can be identified as willing buyers. For example, water utilities benefit from good farming practices upstream to maintain raw water quality; future carbon savings from woodland creation or peatland restoration can be measured and credited to investors; the amenity benefits of urban green space are partially captured within local residential property prices. Intermediaries (organisations who act as brokers to coordinate buyers and sellers) and knowledge providers are also important actors in the functioning of such schemes. In practice, a range of technical, financial, cultural and institutional challenges may need to be overcome to establish effective payment or investment schemes.

There is growing interest in unlocking greater flows of private investment in natural capital. Research for Defra identifies six project models that have potential to generate revenue under current or near-term policy conditions:

New woodland creation – supported by revenues from timber and carbon credits over the long term. Projects may take the form of traditional plantations, community forests or agroforestry projects.

Peatland restoration – supported primarily by carbon credits (based on the UK Peatland Code) and potentially biodiversity, water quality or flood prevention benefits.

Biodiversity and natural capital net gain – where developers pay for creating or enhancing natural capital assets to mitigate the impacts of construction and residential development schemes.

Place-based strategic investment – where a charity or social enterprise manages a natural capital asset portfolio, such as urban parks, beaches or a woodland, under a mandate to balance different ecosystem services, including monetisable returns (for example, based on trading, recreational activities and possibly public health benefits) and non-financial public goods (for example, amenity values and air quality improvements).

Integrated catchment services – where there is an opportunity to improve co-ordination between providers of water quality, water resources and flood management services. Projects and opportunities typically involve a mix of public beneficiaries and private funders within a catchment area.

Sustainable urban drainage systems – where water company and other spending on surface water drainage and flood defence is diverted towards green infrastructure as a more cost-effective way of attaining outcomes and providing a range of ecosystem service benefits, such as urban amenity, health and recreation.

Some of these models have in recent years been scoped and tested through a number of Defra pilot projects. The key findings and lessons from that programme have been synthesised, along with a Best Practice Guide to provide detailed practical guidance for

those wishing to design and develop payments for ecosystem service schemes. Tabs in the ENCA Assets Databook reference examples of market-based tools that can support new income streams. ENCA Case Studies provides further real world examples and initiatives.

5.6 Lessons from local application of natural capital approaches

Application of natural capital approaches at a local level is in its infancy. A general review for Defra of this experience, of the benefits and challenges of applying a natural capital approach at local level, has been published.[28] The research draws the following conclusions:

> There are many possible ways in which a natural capital approach can be applied, reflecting the array of decisions that determine the condition of the environment in any one place and the benefits gained from it. They can take many forms, ranging from very detailed analyses to much broader and more general cases for taking action.
>
> Natural capital approaches are aiding progression towards integrated decision making, for example by generating baseline evidence and revealing values not previously considered in decision making.
>
> Pursuit of a natural capital approach is not an end in itself. Natural capital approaches are part of a broader movement towards integrated working that has been advanced over the last decade by various long-standing local environmental initiatives and organisations.
>
> The expression of economic values for natural assets can create a common language for talking about value across sectors.
>
> Integrated decision making is not an inevitable outcome of adopting a natural capital approach. A number of cultural, institutional and technical challenges remain.

To address the challenges and support the wider application of natural capital approaches, the study identified a number of ways forward, including verification of a set of national natural capital assessment techniques, agreed metrics and publicly available baseline data and maps; and building on the NCC's Natural Capital Workbook.

To help support effective natural capital approaches, practitioners can:

- promote a flexible and pragmatic application of the approach
- explore the fit of natural capital with other forms of 'capital'
- identify 'entry points' for applying a natural capital approach and engaging sectors such as health and economic development, for example, specific opportunities for

[28] Collingwood Environmental Planning (2019), *25 Year Environment Plan Local Delivery: Enhancing Local Delivery and Implementation*. Report to Defra.

decision makers where a natural capital approach could help, and finding visible, relatable issues

- make the business case more explicit by building the evidence base on ‘how’ and ‘why’ to use a natural capital approach

For further information, the Ecosystem Knowledge Network is a leading UK forum for sharing practical learning and resources among people who want to put the environment at the heart of decision-making in order to support wellbeing and prosperity. The Network was established by the UK Government in 2012 and has since become self-standing with 2000 members. It brings people together from across sectors including the built environment, local government, financial services, nature conservation, health and economics. Key practical learning resources include:

Natural Capital Assessment Gateway – Uses an interactive map brings together information on the growing number of projects (in progress or completed) in the UK concerned with mapping and assessing natural capital and ecosystem service delivery at the local, regional or national level.

Case studies – Uses an interactive map to demonstrate and provide information on a wide range of case studies from across the UK which are considered good examples of projects using the ecosystem approach.

6 Finding data and evidence for natural capital approaches

The evidence base on natural capital is vast, complex and rapidly expanding, reflecting different evidence needs for different times and contexts. This can make it difficult for analysts to determine what might be suitable for use in value transfer and natural capital applications. The ENCA Service and Assets Databooks have been developed to address this challenge.

In identifying relevant content for a range of users, Defra's Environment Analysis Unit has drawn on its knowledge of the evidence base and the expertise of the Defra network, alongside a thorough review of existing tools and systematic reviews. The two Databooks provide a wealth of selected references, commentary and detailed guidance and physical and valuation metrics across a wide range of environmental effects and asset categories.

See also ENCA Featured Tools for other valuation tools and resources.

6.1 ENCA Services Databook

ENCA collates a wide range of evidence into this Databook. It enables you quickly to investigate key sources for specific environmental impacts, with indicative values where appropriate. It does not provide “total” or “standard” values for particular types of land cover (for example, woodland, wetland), because these will vary according to the characteristics, condition and extent of the asset or effect in question, its location and availability of substitutes.

This Databook collates and make accessible the most nationally relevant and up to date sources, studies and key estimates for 24 categories of environmental service or effect as set out in Annex 1, and provides a conceptual overview of each effect and the various analytical considerations that apply. Importantly, the Databook also includes selected biophysical metrics and sources alongside valuation estimates within each tab.

Notable cross-cutting sources of valuation and biophysical evidence which have informed the Databook include:

- HM Treasury Green Book, Annex A2
- Environment Valuation Reference Inventory, an international valuation database supported by Defra, which includes over 400 UK studies.
- Microeconomic Evidence for the Benefits of Investment in the Environment by Natural England economists
- UK Natural Capital Accounts, by the Office for National Statistics in partnership with Defra.
- Environment Valuation Look-up tool, developed for Defra in 2015.
- UK National Ecosystem Assessment.

Supplementary Evidence Report for the 25 Year Environment Plan by Defra's Environment Analysis Unit

These sources can be reviewed in their own right, particularly if users cannot find what they are looking for. By its very nature, this Databook is not exhaustive and indeed the user may have available more specific or relevant evidence for their needs. For example, numerous small-scale valuation studies have been undertaken over the years in different locations and spatial contexts. These may still be relevant for use in similar localised contexts, subject to application of value transfer principles.

Key considerations in using any source from the Databook include:

- age – when was it developed; are more recent editions available?
- definitions – these may be different to your own
- spatial detail – is it suitable for your needs?
- quality assurance - has it been quality assured in any way, such as a peer review or any accreditation?
- methodology – was it developed using a robust, suitable approach?
- inputs – if based on a model is it using good quality data?

The detailed notes within each Tab can help inform your answer to these questions, but it is recommended that you view the original sources (links are provided) in order to check that you are applying the original estimates in an appropriate manner using value transfer principles. It is essential to cite the original source or study in your work alongside any reference to the ENCA Databook.

6.2 ENCA Assets Databook

This Databook collates and summarises selected valuation studies relevant for specific broad habitats. Rather than directly report specific estimates, it provides annotated references to:

- available UK Natural Capital Accounts evidence for each broad habitat
- 25 Year Environment Plan Indicators, based on the natural capital framework
- Natural England's Natural Capital Indicators for defining and measuring change in natural capital
- selected biophysical data, evidence and tools by habitat
- selected valuation tools and evidence by habitat
- market-related tools

Datasets by natural asset categorisation as set out by the Natural Capital Committee can be found in Annex 6 of its Natural Capital Workbook. Many of these resources are referenced under the Broad Habitat breakdown within the Databook.

When making use of sources, the same considerations apply as for those set out in relation to the Services Databook. It is essential to cite the original source or study in your work alongside any reference to the ENCA Databook.

Annex 1 Environmental effect categories

Natural capital in market outputs (provisioning and abiotic services)

Natural capital provides a range of tangible goods and flows that provide economic inputs. These are known as provisioning services and abiotic flows, as detailed in the table. They are often included in trade-offs with other ecosystem services, for example a reduction in food production may be associated with an increase in water quality.

Service provided by natural capital	Description	Final benefits of (an improvement in) the good
Food	Food in its various forms is produced by a range of ecosystems. Food can be directly consumed (wild fruit, angling) or be realised through processing of a provisioning service from raw material (crops) to final good (bread). The boundary between what is provided by natural capital and the contribution of other forms of capital is often a grey area for example, crops require agricultural management; livestock depends upon grassland ecosystems.	Food for human consumption
Timber	Historically, raw timber has been the dominant use of UK woodlands and remains an important provisioning service supplying the UK forestry sector. Raw timber has a range of final uses including furniture, building materials, fuel and paper.	Harvested timber for further processing
Fish	The marine environment is a major source of food for human consumption. Most fish is captured from the sea, with small amounts from freshwater and increasingly from aquaculture.	Seafood for human consumption
Water supply	Water is a vital resource that needs to be managed carefully to ensure that people have access to affordable and safe drinking water and sanitation. Furthermore, to ensure that the needs of industry are met, without depleting water resources or damaging ecosystems	Industrial, agricultural and public water supply uses
Minerals	Minerals are naturally occurring substances formed by geological processes; other sub-soil assets include rocks, aggregates and fossil fuels (oil and gas)	Minerals for various industrial uses; energy services

Service provided by natural capital	Description	Final benefits of (an improvement in) the good
Peat	Extraction of peat occurs in Northern Ireland, Scotland and England, mainly for horticultural use. Extracted peat results in loss of the peat resource and carbon emissions. Extracted peat will eventually be oxidized to CO2, creating an additional emission source.	Various horticultural and industrial uses
Renewable energy	Natural capital is critical for the siting and production of various forms of renewable energy: onshore and offshore wind power; hydro power and bio-energy. These renewable sources (other than biomass) are not strictly produced by the functioning of ecosystems but rather by climate and geography.	Energy services

Natural capital can reduce harmful externalities (regulating services)

Regulating services are ecological processes that regulate and reduce pollution and other adverse effects. Their value is dependent not only on the extent and condition of the ecosystem, but also on the extent of harmful effects that they help to lessen, and on the location of beneficiaries. They are often valued by reference to avoided damages or the costs of alternative approaches to reducing the harm.

Service provided by natural capital	Description	Final benefits of (an improvement in) the good
Air pollutant removal	Air pollution presents a major risk to human health, resulting in premature deaths and reduced quality of life. By improving air quality, vegetation helps to lessen these impacts on health and wellbeing. The level of the service is positively related to (a) the amount of background pollution; (b) the amount of vegetation; (c) the density of population affected. Woodland is the major service provider.	The benefit is reduced health costs from lower levels of pollution exposure than would otherwise be the case

Service provided by natural capital	Description	Final benefits of (an improvement in) the good
Carbon sequestration	A natural function of ecosystems is to sequester carbon dioxide from the atmosphere and store it. This varies between broad habitats. Any change in land-use, restoration or enhancement of ecosystems has a measurable effect on the quantity of GHG emissions. Tree planting will lead to increased sequestration, reducing GHGs emissions in the atmosphere. Degraded habitats such as upland peat emit carbon dioxide, and their restoration will reduce the level of emissions.	Contribution to meeting national GHG targets to avert damaging climate change. The final benefits of mitigating climate change (involving extreme weather events) are far broader and longer term, both home and abroad.
Water flow regulation	Relative to bare soil or managed grassland, woodland reduces flooding risk to downstream populations by reducing rainfall flows entering rivers. This ecosystem service also applies in urban areas, where vegetation can reduce surface water flooding from heavy rainfall, with benefits to sewer capacity. Coastal flood risk is reduced by habitats such as saltmarsh. The valuation of flood damage itself (for which engineering solutions are typically deployed) can be found in the Floods tab of the ENCA Services Databook.	Reduced flood damage to downstream or coastal settlements as a result of reduced magnitude / frequency of flood / storm events; and / or lower sewer capacity or water storage costs
Noise mitigation	Noise pollution is associated with adverse health outcomes through lack of sleep and disturbance. According to the World Health Organisation it is the second largest environmental health risk in Western Europe. Vegetation can protect against noise pollution, by acting as a physical buffer between the source of the noise and those living nearby. This is particularly relevant in urban areas. Noise regulation by vegetation is highly spatially specific and is dependent upon sufficient height, depth, permeability and of vegetation to absorb noise. There has been no systematic attempt to value this service until the development of UK urban accounts by ONS and Defra.	Reduced noise disturbance giving wellbeing and productivity benefits

Service provided by natural capital	Description	Final benefits of (an improvement in) the good
Local climate regulation	Urban economic activity can be significantly impacted by hot summer temperatures. Woodland, grassland, gardens and open waters in urban areas reduce air temperature and so reduce these heat-related costs. Consequently, the creation or loss of urban vegetation will marginally affect this service. Temperature regulation will become more significant in future as climate change is expected to lead to hotter summers and more frequent heatwaves.	A more equable climate, reducing labour productivity losses and air conditioning costs
Waste remediation	Ecosystems can provide a sink capacity for various forms of organic or inorganic waste and lessening their harmful impact for example, bio-remediation of industrial wastes by disposal on agricultural land	Avoided treatment costs

Natural capital supports cultural, health and recreation benefits (cultural services)

Cultural services are provided by the various environmental settings that enable various forms of cultural interaction and activity. They include the active or passive use of natural assets for a range of human pursuits including recreation, exercise, education, science, volunteering, cultural and religious activities. Some of these motivations can be difficult to disentangle. In many cases cultural services will also depend upon human and man-made capital, including historical and heritage assets. The UK National Ecosystem Assessment Follow-On Phase emphasises that cultural services involve cultural values as well as environmental spaces and give rise to a range of wellbeing benefits based on identities (like rootedness), experiences (like tranquillity) and capabilities (like health).

Service provided by natural capital	Description	Final benefits of (an improvement in) the good
Environmental settings for recreational use, enjoyment and tourism	The recreational value of natural spaces reflects both the natural setting and the facilities on offer at the site and often has a strong non-market element. It varies with the type of habitat, location, population density and the availability of substitute recreational opportunities. Recreational values can be affected directly by enhancements in green spaces, or adversely if they are affected by new developments or infrastructure. Related to recreational values are the benefits to tourism where recreational activity involves longer stays and economic production focused on outdoor leisure.	Use values to individuals visiting outdoor recreational sites; these can also include physical and mental health benefits.
Settings for physical activity	Inadequate physical activity is associated with higher risk of obesity, coronary heart disease, diabetes, stroke, some cancers and mental ill health - all of which impose a large cost burden on society. Natural environments offer settings and opportunities for informal physical activity which enable many individuals to achieve recommended guidelines for weekly physical activity, and so can be valued.	Health sector cost savings; reduced morbidity; increased economic output
Environmental settings for mental health	Personal interaction with and exposure to green space	Health sector cost savings; increased economic output
Enabling educational interactions	Engaging with nature can lead to increased environmental knowledge and general learning experiences, supporting learning and attainment. The service can operate in different contexts, for example from pre-school and primary school children and special needs groups through to secondary school pupils, undergraduates and research students.	The various educational benefits associated with outdoor learning; additional earning power arising from ecological knowledge
Volunteering	An important aspect of volunteering is the benefits to society of volunteering opportunities (e.g exercise, social contacts, training, preparing people for employment etc). These benefits are particularly relevant because environmental interventions, particularly by the third sector, but also by others, may involve or even rely on input by volunteers.	Labour resource savings would be a lower bound of various use and non-use values.

Bundled benefits

Often in practice, the natural environment produces a bundle of services jointly, and it may not be obvious to identify or quantify precisely which ecosystem services are involved. Non-use as well as use values may be included. These aggregated or bundled benefits tend to be cross-cutting or relate to policy areas or specific assets such as soil. Double-counting can be an issue if these are added alongside specific individual services.

Category	Description	Final benefits of (an improvement in) the good
Biodiversity	Nature's diversity, commonly referred to as 'biodiversity', is the variety of life on Earth. It includes all species (animals, plants, fungi etc) and the natural systems and habitats that support them.	Biodiversity underpins to varying degrees all ecosystem services. Species (micro-organisms, fungi, plants etc) underpin all services that provide inputs to production (such as food, timber) and services that regulate the environment (such as maintaining water quality). They also directly contribute to people's interactions with the environment (for example, nature watching) and can improve the level and stability of ecosystem services.
Local environmental amenity	"Amenity" loosely refers to a bundle of cultural services that arise from being close to natural assets, including aesthetic and visual benefits, tranquility, and recreational opportunities. Conversely, activities such as waste disposal and quarrying impose local social costs such as noise, congestion, dust, odours and visual intrusion.	Aesthetic and visual benefits, the option value of local recreation, perceived mental or physical health benefits from better quality natural assets.
Water quality	Poor water quality is both a result of a variety of drivers (from agriculture, housing, industry, transport) and a cause of multiple costs in welfare terms.	Recreational benefits for anglers, rowers, other users of riparian habitat (walkers, bird watchers), more general local amenity benefits, as well as lower costs of water treatment.

Category	Description	Final benefits of (an improvement in) the good
Landscape	Landscape provides the setting for people's day-to-day lives. It does not only refer to special or designated landscapes or the countryside.. The generic category of "landscape" is closely associated with the more specific cultural service categories of "environmental settings", but here the focus is more on wider landscapes that give rise to a range of cultural and aesthetic benefits.	Opportunities for recreational activities including nature watching, hiking, and the opportunities to experience views, sounds and scents. It can include aesthetic experience, visual amenity as well as cultural heritage.
Soil health	Healthy soils perform multiple functions, including storage of carbon, infiltration and transport of water, nutrient cycling, and provision of food. These are threatened by soil erosion, loss of soil carbon and soil compaction.	Reduced GHG emissions, reduced water treatment costs, reduced flood risk, crop yield gains
Non-use values	The value of the benefit of knowing that an aspect of the environment exists and is being maintained. These are particularly relevant to aspects of the environment that people express strong preferences for (such as charismatic species, special habitats, landscapes and heritage) Species, ecosystems, landscapes, environmental settings can all provide non-use as well as use values.	All benefits relate to individuals. These include (i) Existence value: the satisfaction of knowing that an ecosystem continues to exist (ii) Bequest value: the benefit of knowing that an ecosystem will be passed on to future generations so that they will have the opportunity to enjoy it; (iii) Altruistic value: the satisfaction gained from ensuring that an aspect of the environment is available to others in the current generation.

Negative environmental effects

These are the traditional environmental "externalities" which are caused by man-made sources or pressures. Some may be specific flows, others are bundled. Reversing a negative environmental impact represents an environmental benefit. These are to be distinguished from the more general concept of “environmental pressures” within the natural capital framework (climate change, resource use, chemicals and biosecurity), which directly affect the extent and condition of natural assets. The effects here directly impact on people’s welfare.

	Description	Benefits of reducing the externality
Air pollution	Atmospheric pollution can have significant effects on health, quality of life, economic activity and the functioning of ecosystems.	Improvements to physical health and mortality
Noise	Noise is any unwanted sound. It can arise from construction and industry and road, rail and air transport.	Improvements to physical health and wellbeing, and productivity
Flooding	The most common forms of flood are: river flooding after heavy rainfall in waterlogged catchments; coastal flooding from tidal surges; and surface water flooding when sewers are overwhelmed by heavy rainfall or become blocked.	Reduced or avoided damages to property, human health and agricultural production
Waste and disamenity	Activities such as waste disposal and quarrying impose local social costs such as noise, congestion, dust, odours and visual intrusion.	Aesthetic and health benefits
Non-native invasive species	Non-native invasive species have significant impacts on the health of ecosystems as well as economic damage for instance damage to buildings and crops.	Reductions in financial damage and control costs

Annex 2 Economic valuation methods

Conceptually, the economic value of a positive change in the natural environment is typically measured by what individuals are willing to pay to secure this benefit. By contrast, the economic value of a negative change is measured by what individuals are willing to pay to avoid such a cost. The appropriate methods to elicit estimates of value will typically vary across the different categories of economic value. Valuation methods can be broadly divided between “revealed preference” “stated preference” and cost-based approaches. Non-use values will typically require stated preference methods, whereas use values will typically be based on market or revealed preference methods.

Revealed preference / market-based methods

These rely on data regarding individuals’ preferences for a marketable good which includes environmental attributes.

Market prices – these can be used to capture the value of goods and services that are traded, such as the market value of forest products. Even where market prices are available, they may need to be adjusted to take account of distortions such as subsidies. In natural capital accounting, market prices can inform the calculation of resource rent, which is the proportion of market output value attributable to the natural asset (for example, the value of the soil as a proportion of crop output)

Production function – this approach focuses on the relationship between a particular ecosystem service and the production of a market good. Environmental goods and services are considered as inputs to the production process and their value is inferred by considering the changes in production process of market goods that result from an environmental change. This approach is capable of capturing indirect use value, for example, the contribution of pollinators to fruit tree production.

Averting behaviour - this approach focuses on the price paid by individuals to avoid environmental costs. For instance, the cost of water filtration may be used as a proxy for the value of water pollution damages; or costs of buying pollution masks to protect against urban air pollution (although this will only represent part of the damage value). It is closely linked to replacement costs (see below).

Hedonic pricing - this assumes that environmental characteristics (such as a pleasant view or the disamenity of a nearby landfill site) are, through the conscious and unconscious choices of many buyers over time, reflected in property prices. The value of the environmental component can be revealed by modelling the impact of all possible influencing factors on the price of the property, including environmental factors. Hedonic pricing can measure direct and indirect use value.

Travel cost method - a survey-based technique that uses the costs incurred by individuals taking a trip to a recreation site (travel costs, entry fees, opportunity cost of time) as a

proxy for the recreational value of that site. It captures use value; visitors to the site may hold non-use values, but these cannot be assessed using this valuation method. Random utility models (for example, see ORVal) are an extension of the travel cost method and are used to test the effect of changing the quality or quantity of an environmental characteristic at a particular site.

Stated Preference methods

These use carefully structured questionnaires to elicit individuals' preferences for a given change in an environmental resource or attribute. Although they are not based on actual economic choices and so are subject to various biases, stated preference methods have two advantages. First, they can be applied in a wide range of contexts and, second, they are the only methods that can estimate non-use values which can be a significant component of overall total economic value for some natural assets.

Contingent valuation is a survey-style approach that constructs a hypothetical market via a questionnaire. Respondents answer questions regarding what they are willing to pay for a particular environmental change.

Choice modelling is a survey-style approach that focuses on the individual attributes of the ecosystem in question. For example, a lake may be described in terms of water quality, number of species, alongside some type of fee. Participants are presented with different combinations of attributes and costs and asked to choose their preferred combination or rank the alternative combinations. Each combination of attributes has a price associated with it so respondents reveal their willingness to pay for each attribute.

Cost-based approaches

These approaches consider the costs in relation to provision of environmental goods and services and only provide 'proxy' values.

Damage costs method - estimates the value of an ecosystem service according to the damages that would be inflicted in the absence of that service. This is relevant for regulating services (such as air filtration, flood regulation, noise mitigation) and would provide an upper bound of willingness to pay. Damage costs may be based on objective assessments, such as property damages, or subjective stated preference methods related to avoiding noise or illness.

Replacement cost method - considers the cost of providing a substitute good / engineering solution that performs a similar function to the environmental good. For example, wetlands that provide flood protection may be valued on the basis of the cost of building man-made defences of equal effectiveness. Since wetlands provide a range of ecosystem services, this costing would be a minimum estimate of the value of a wetland. For replacement costs not to overstate the true economic value the following three conditions must hold: the estimate of the costs reflects the qualities of the ecosystem service being lost; the

replacement is the least-cost alternative; and the replacement would actually be fully demanded in the absence of the asset.

Opportunity cost method - considers the value forgone in order to protect, enhance or create a particular environmental asset. For example, the opportunity cost of agricultural production lost if land is retained as forest.

Restoration cost method - looks at the cost of restoring a damaged asset to its original state and uses this cost as a measure of the benefit of restoration. The approach may be favoured where cost estimates of such costs are more readily available, but it cannot of itself value the benefits because of the circular logic involved.

Annex 3 Glossary

This glossary has drawn on number of other glossaries: Natural England's Microeconomic Evidence for the Benefits of Investment in the Environment; Defra's 2010 Introductory guide to valuing ecosystem services; HM Treasury's Green Book; and the UN's The Economics of Ecosystems and Biodiversity.

Abiotic – Not derived from living organisms; associated with physical as opposed to biological

Appraisal – The process of defining objectives, examining options and weighing up the relevant costs, benefits, risks and uncertainties before a decision is made

Asset – A resource that provides a flow of benefits over a period of time

Asymmetric information - Imperfect or asymmetric information arises where one party has more information than another, leading to economically inefficient outcomes.

BCR (Benefit-Cost Ratio) – The ratio of benefits to costs of an intervention or decision arrived at using an appraisal

Benefits – Positive impacts on wellbeing

Biodiversity – Variability among living organisms from all ecosystems of which they are part, covering richness, rarity, and uniqueness

Biophysical environment – The biotic and abiotic surroundings of a population

Biotic – Derived from living organisms

Broad habitat – High-level classification of ecosystems that characterise and make up the UK's natural environment. Eight broad habitats are defined.

Carbon sequestration – The uptake and storage of carbon, for instance by absorption of carbon dioxide by trees and plants which then release the oxygen

Choice-modelling – A technique that models the decision process of an individual in a given context (via revealed preferences or stated preferences)

Consumer surplus – The benefits enjoyed by consumers when the price they pay for a good or service is lower than the maximum they would be willing to pay

Contingent valuation – Stated preference based economic valuation technique based on a survey of how much respondents would be willing to pay to obtain a good or service or how much they would be willing to accept

Cost-Benefit Analysis – Quantification in monetary terms of all possible costs and benefits of a proposal, including those that do not have substantive market values attached to them

Cultural services – The non-material benefits people obtain from ecosystems for instance through spiritual enrichment, cognitive development, recreation, and aesthetics

Direct use value – Benefits derived from services provided by an ecosystem that are used directly by individuals for example, recreational value derived from actually visiting a park

Disamenity value – Welfare losses as a result of nuisance for instance noise, odour, litter, visual intrusion etc.

Discounting – A method for translating future costs or benefits into present values using a discount rate

Displacement – The extent to which an increase in economic activity spurred by an intervention is offset by a reduction in economic activity elsewhere

Disservices – Undesired negative effects on human wellbeing from the functioning of ecosystems (for example, reduced agricultural productivity due to pest species)

Double-counting – An error that occurs when costs and benefits are counted twice in an economic analysis. This occurs often when the value of variables feeds into one another in stages to result in a final benefit/cost

Ecological/environmental threshold – The point at which pressures on the condition of an ecosystem result in a non-linear or abrupt transition to a new state

Economic efficiency – Allocation of resources in the most productive manner such that it is not possible to make someone better off without making someone else worse off

Economic growth – An increase in the output and income of an economy, measured as gross domestic product (GDP), over a period of time.

Economic impact – The impact of a proposed intervention (new, not displaced) on the economy (usually measured through a change in GVA or employment)

Economic valuation – Assignment of monetary values to a particular good or service in a certain context (such as decision-making)

Ecosystem – A dynamic complex of living things (animals, plants and micro-organisms) and their physical environment interacting as a functional unit

Ecosystem services – Functions of the natural environment, that directly or indirectly provide benefits for people

Evaluation – A systematic assessment of policy or intervention covering its design and/or outcomes

Exchange value – the value of real or hypothetical transactions of a good or service between buyers and sellers in an actual or hypothetical market.

Existence value – The value that individuals place on the knowledge that a resource continues to exists, whether or not they use that resource themselves

Externalities – The positive or negative consequences of an activity for those not involved in carrying out that activity

GDP (Gross Domestic Product) – The value of output or national income of a country over a 12-month period

GDP deflator – An index of the general price level in the economy, measured by the ratio of Gross Domestic Product (GDP) in nominal terms to GDP at constant prices

GVA (Gross Value Added) – The sum of values added by all industries in a country, including subsidies but excluding taxes, over a 12-month period

Green infrastructure – A network of multi-functional greenspace, urban and rural, which is capable of delivering a wide range of environmental and quality of life benefits for local communities.

Habitat – A place where an organism or community of organisms normally live

Hedonic pricing – A revealed preference valuation method that estimates the use value of a non-market good or service by examining the relationship between the non-market good (environmental attribute) and the demand for some market-priced complementary good (such as property prices)

Impact pathway approach – A systematic approach to the assessment of a policy or intervention in terms of its impact on ecosystem services and resulting welfare implications

Indirect use value – The benefits derived from ecosystem services that are used indirectly by an economic agent

Instrumental value – Valuing the environment from the perspective of its benefits to people and the economy. This contrasts with “intrinsic value”, which posits that nature has value by, in, or for itself, irrespective of whether humans benefit from it.

Marginal abatement cost – The incremental cost of additional reductions in a negative environmental impact

Marginal change – The change in value resulting from one more unit of a good or service produced or consumed

Market failure – When the market mechanism alone is unable to achieve economic efficiency, for varying reasons.

Meta-analysis – A statistical method of combining a number of valuation estimates that allows the analyst to systematically explore variation in existing value estimates across studies, for value transfer purposes

Multi-criteria Decision Analysis – A technique for dealing with decisions in a context where multiple goals cannot be reduced to single monetary values

Natural capital – Stock of natural assets which provide benefits to people in the form of tangible things which are typically marketed (such as timber, fish stocks, minerals) and less tangible services (such as air purification, recreational settings and flood prevention)

Net-Present Value –. The sum of a stream of future values discounted at an appropriate discount rate (such as the Green Book social discount rate) to bring them to today’s value

Non-use or passive use value – Benefit values (altruistic, bequest, and existence values) derived by individuals which are not associated with direct or indirect use of a resource

Option value – The value placed by individuals on having the option to use a resource in the future

Precautionary principle – A principle stating that in cases ‘‘where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation,’’ as defined in the Rio Declaration.

Primary valuation – An economic valuation study providing new estimates for decision-making by estimating the value of the change in a policy good

Producer surplus – The benefit obtained by a producer when they receive more in price for a product than the minimum amount they would be willing to accept

Production function – The relationship that may exist between a particular ecosystem service and the production of a market good.

Provisioning services – The products obtained from ecosystems for example, genetic resources, food and fibre, and fresh water

Public good – A good or service that is non-rival and non-excludable i.e. the consumption of the good by one individual does not reduce availability of the good for others and access to the good cannot be restricted

Quasi-Option value – The value of preserving options for future use of an environmental resource by delaying a decision, where outcomes are uncertain and where there is an opportunity to learn by delay

Real terms – The value of expenditure at a given general price level such that the impact of inflation is removed (calculated by dividing a nominal cash value by a general price index)

Regulating services – The benefits obtained from the regulation of ecosystem processes, for example, the regulation of climate, water, air quality, human diseases and erosion control

Replacement cost – The costs of replacing ecosystem services with human engineered technologies

Revealed preference – Economic valuation methods that use the actual observation of consumer behaviour to define consumer preferences

Sensitivity analysis – A study of the sensitivity of expected outcomes of an intervention to potential changes in key input variables under a given set of assumptions. It can therefore be used to test the impact of changes in assumptions on the outcome variable of an appraisal

Shadow price – Estimated value of a good or service where market prices are not available, or do not reflect total costs and benefits

Social costs and benefits – The total costs and benefits of an action to society – including private costs/benefits to individuals as well as additional costs/benefits to society as a whole

Species diversity – Biodiversity at the species level, combining aspects of species richness, relative abundance, and dissimilarity

Stated Preference methods – Economic valuation methods that use survey questionnaires to elicit individuals' preferences (i.e. willingness to pay and/or willingness to accept) for non-market goods or services

Supporting services – Ecosystem services that are necessary for the production and maintenance of all other ecosystem services. For example soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat. These services often reflect the function and condition of natural capital stock

Sustainability – Meeting the needs of the existing population without compromising the ability of future generations to meet their own needs

Total Economic Value – The value obtained from the various constituents of utilitarian value, including direct use value, indirect use value, option value, quasi-option value, and existence value

Travel cost method – A revealed preference valuation method that infers the value of a recreational site from the cost incurred by individuals traveling to that site (their demand function for visiting that site)

Use value – Value derived from using or having the potential to use a resource. This is the net sum of direct use values, indirect use values and option values

Utility – A measure of the satisfaction gained from a good or service. Synonymous with economic welfare.

Valuation – Assignment of values to a particular good or service in a certain context (such as decision-making) in monetary or other terms

Value transfer – The process of inferring the size of an economic benefit or cost at the site under consideration from previous research at another site, paying careful attention to contextual changes

Welfare – A measure of the satisfaction that individuals gain from the consumption, experience or existence of a good or service, whether or not those are marketed.

Willingness to Accept – monetary measure of the value of forgoing an environmental gain or allowing a loss

Willingness to Pay – monetary measure of the value of obtaining an environmental gain or avoiding a loss