Department
for Environment
Food & Rural Affairs

Enabling a Natural Capital Approach guidance

February 2026

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We work closely with our 33 agencies and arm's length bodies on our ambition to make our air purer, our water cleaner, our land greener and our food more sustainable. Our mission is to restore and enhance the environment for the next generation, and to leave the environment in a better state than we found it.

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Contents

This guidance is intended for those looking to learn about natural capital and how to apply it. It forms part of a suite of Defra resources collectively called 'Enabling a Natural Capital Approach' (ENCA).

ENCA is recommended for use by HM Treasury's Green Book: appraisal and evaluation in central government (2026) and represents supplementary guidance to the Green Book.

Natural capital has a wide range of applications and so this guidance aims to meet the needs of various users.

This table signposts relevant sections of this guidance and the wider ENCA resource, according to user interest.

I am interested in	Check section	Other ENCA resources
An overview of natural capital and its relevance	1	
Applying HM Treasury Green Book guidance on Natural Capital	3	ENCA Assessment Template
Understanding whether my proposal will affect nature	3.3 to 3.4	ENCA Featured Tools
How ENCA can support my policy priorities	3.2 and Annex 1	ENCA Case Studies
Find monetary values for environmental effects	2 and 6	ENCA Services Databook, ENCA Assets Databook ENCA Featured Tools
Assessing natural capital that I own or manage	4 and 5.1	
Developing a natural capital account	4	
Experience with natural capital approaches	3.5 and 5.6	ENCA Case Studies
Tools and data	5.2 and 7	ENCA Featured Tools

Local economic development	5.4 and Annex 1	
Generating new income streams to support the natural environment	5.5	ENCA Case Studies

For a more detailed ‘roadmap’ of what ENCA can offer for specific cross-cutting themes of policy interest, check Annex 1 of this guidance.

This version of the ENCA guidance updates that of July 2023, in particular including additional guidance on valuing biodiversity (Section 2.8), Proportionality in appraisal (Section 3.4) and Generating new income streams (Section 5.5).

1. Introduction to natural capital

1.1 What is natural capital?

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.

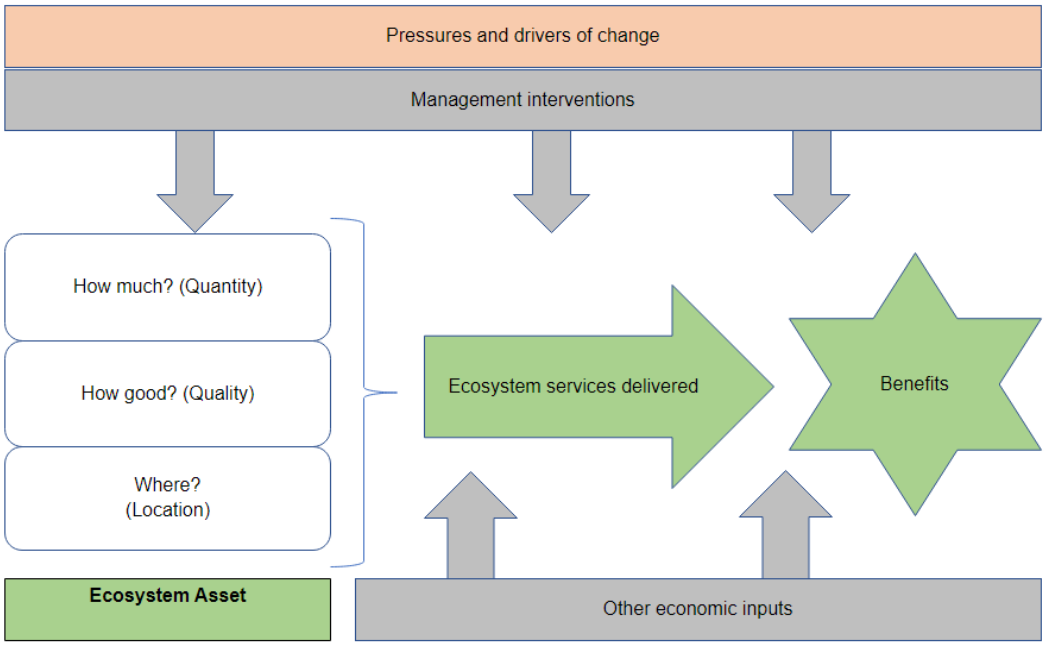
These include use values that involve interaction with the resource and which can have a market value (minerals, timber, freshwater) or non-market value (such as outdoor recreation, landscape amenity).

They also include non-use values, such as the value people place on the existence of particular habitats or species.”

The ability of natural 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 to realise benefits. In other cases, the benefit follows directly from the service without further capital or human input (Figure 1).

Figure 1: The Natural Capital Framework



1.2 Why take a natural capital approach?

Taking a natural capital approach develops our traditional understanding of how the economy works - in which various kinds of capital provide flows of benefit to households and firms.

Natural capital forms part of our natural wealth, alongside traditional assets such as infrastructure, skills, buildings and technology. This framing helps us to account for its contribution to the economy, and the range of social and economic benefits and opportunities that come from investment in those assets. Pressures on nature result in costs to the economy.

Understanding nature as a set of assets that benefit people and society in all kinds of ways can support better decision-making. This helps us to give the best public value given that there are scarce resources and trade-offs between objectives. It reduces the risk of the value of the natural environment being ignored in decision making.

Natural capital has become a standard analytical approach to thinking about nature, following the seminal UK National Ecosystem Assessment (2011 and 2014) and the work of the Natural Capital Committee. 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.

Natural capital assets can overlap with cultural and heritage assets. Check the Culture and Heritage Capital framework and evidence base being developed by the Department for Culture, Media and Sport.

1.3 Is there a single natural capital approach?

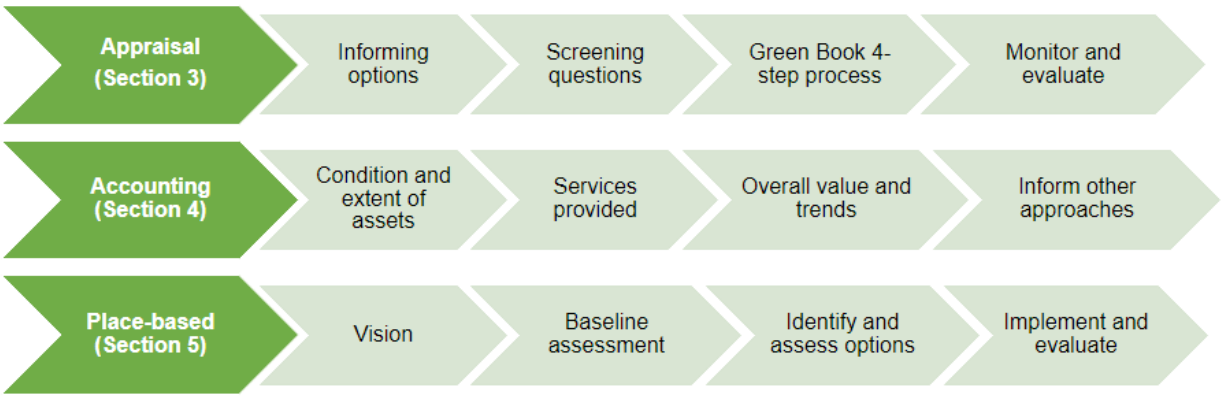
Various research and analytical models, tools and methods seek to apply this framework and they continue to evolve.

This guidance is structured around 3 linked, but distinct, applications of natural capital framework:

- incorporating natural capital into policy or project appraisal (section 3), building on HM Treasury's Green Book Appraisal guidance
- natural capital accounting (section 4), building on the work of the Office for National Statistics to develop UK natural capital accounts
- place-based implementation of natural capital principles (section 5)

Each involves a staged approach, summarised in Figure 2.

Figure 2: different spheres of natural capital approach



Common to all these is potential for economic valuation of the environment, although a natural capital approach does not always require monetary valuation (Check section 2).

In practice, a natural capital approach depends on the context and what you are trying to achieve. This may include one or more of the following:

- assessing baseline levels of natural capital to raise awareness, or inform targets
- development of a natural capital plan to identify priorities and opportunities for land use and management (Check section 4 and Section 5.1)
- using nature to find ways to support policy objectives, whether or not they are environmental (Check section 3.2 and section 5.5)
- providing a rounded assessment of the potential costs, benefits and risks of an intervention on a range of natural assets and their effects on welfare (Check section 3.4)
- developing an understanding of the science and economic value of ecosystem services, which can inform accounting and appraisal exercises as well as strategic initiatives (Check section 6)
- informing a strategic objective, for example around concepts of net gain, growth of natural assets over time or applications to project-level decisions (Check section 5.3)
- consideration of the spatial variation of natural assets or impacts on them, and how this affects their valuation
- including natural capital as an integral part of development, regeneration and place-making, or as “green infrastructure” (Check sections 5.3 - 5.4)
- identifying potential income streams from natural capital investment (section 5.5)

Annex 1 provides a means of navigating the various ENCA resources from different topical perspectives

For private sector organisations, the Natural Capital Protocol has been developed internationally as a decision support framework that helps organisations to identify, measure and value their impact and dependency 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.

Further guidance on using tools can be found in section 5 and examples of natural capital approaches can be found in ENCA Case Studies.

1.4 Does a natural capital approach require specialist expertise?

ENCA aims to minimise the need for specialist expertise. It enables general users to undertake strategic thinking around natural capital, ‘ask the right questions’, access relevant evidence and tools, apply methods, and become intelligent customers where specialist expertise is used.

Where detailed assessment is required, in appraisal, accounting or place-based contexts, input from natural scientists and economists will usually be needed.

1.5 When to consider a natural capital approach

A natural capital approach can provide a strategic basis for how the natural environment can be integrated with and deliver wider socio-economic outcomes.

A natural capital approach may be used to support application of the environmental principles. The Environmental principles policy statement explains how to interpret and proportionately apply the principles to help improve environmental protection and sustainable development.

The 5 principles are:

- integration
- prevention
- rectification at source
- polluter pays
- the precautionary principle

The natural capital framework can be used to effectively “integrate nature into policymaking, including appraising policy impacts on nature, and using nature investment to meet broader policy goals” (HM Treasury Green Book). Read section 3 for how to do this.

A natural capital approach can help organisations to assess needs, identify dependencies on natural assets and translate this into relevant information for decision making.

It can also support public authorities to decide on what action to take as part of the duty to conserve and enhance biodiversity. Check section 1.7 on biodiversity as a core component of natural capital.

1.6 Types of natural capital

Natural capital stocks or assets can be conceptualised in different ways. A common practical approach is a division in 8 ‘broad habitat types’ (Table 1). Each of these in principle represents a distinctive spatial area which can be combined like a jigsaw puzzle. These classifications underpin the UK Natural Capital Accounts and Natural England’s Natural Capital Atlas Maps. They are also the structure for the definition of natural capital to include all natural elements (such as atmosphere, climate and subsoil assets) whether based on ecosystems or not.

For appraisal and accounting purposes it makes sense to define natural capital according to broad habitats. This enables a distinction to be made between negative externalities such as air pollution, noise and climate change, that affect the natural environment, 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 52% of land area and supplies the majority of the UK’s food. Enclosed Farmland is also of great cultural significance and is a major determinant of landscape in much of lowland UK. The 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 11% of the UK land area.

Freshwater	Freshwaters include open waters, wetlands and floodplains, which cover about 5% of the UK. Freshwater habitats are a major source of water for a wide range of uses and are important for recreation and hazard (notably flood) regulation.
Woodland	Includes managed plantations as well as ancient, semi-natural woodlands. Woodlands cover 13% 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 2% of the UK's land area. They are of immense cultural 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 3 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 around 10% of UK land cover.

An alternative approach which seeks to describe the underlying natural assets was set out by the Natural Capital Committee. This is wider than broad habitats as it includes the atmosphere within the definition of natural assets.

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

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

Geodiversity

A further category underpinning natural asset and broad habitat typologies is that of geodiversity.

Geodiversity is defined by Natural England as ‘the natural range of geological (rocks, minerals, fossils), geomorphological (landforms, topography, physical processes), soil and hydrological features. It includes their assemblages, structures, systems and contributions to landscapes’.

An understanding of geodiversity and its evidence can be a key part of a natural capital approach. It can support ecosystem services (such as water regulation, education and tourism), and inform approaches to climate change adaptation and landscape -scale nature conservation.

Read Natural England’s Summary of Evidence: Geodiversity (2015) for further information and evidence.

1.7 Biodiversity is a core component of natural capital

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). Biodiversity, although complex, forms the living component of natural capital, with a range of effects on social and economic welfare. Biodiversity:

- underpins the ecological condition and quality of ecosystems that support the services provided to people and the economy
- directly benefits people through the existence of valued species, 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

Biodiversity is represented in the Natural Capital Committee's typology as ‘species’ and ‘ecological communities’ (Table 2). It supports the benefits provided by all 8 broad habitat types. Biodiversity may be the subject of a strategic constraint or goal for a policy, programme or project, such as:

- options to avoid a net loss of biodiversity as measured by a biodiversity metric
- a target to create or restore a certain quantity of biodiversity rich habitat

Policies or projects will impact biodiversity if they are likely to cause the following types of changes:

- gains or losses in the variety and abundance of or within species (for example, because of changes to wildlife control and management, changes to farmland management, or any land use change)

- gains or losses in the amount of space for ecosystems and habitats (for example, because of building development, or changes in land use)
- gains or losses in the physical connectedness between ecosystems and habitats (for example, because of transport developments)
- environmental changes within ecosystems and habitats (for example, arising from changes in any type of pollution, or restrictions of water supply)

The 2021 Environment Act includes a strengthened biodiversity duty and Environmental principles (see 1.5 above), as well as national biodiversity targets and biodiversity net gain (see 5.3 below). So, it is now more important for policy makers to consider strategically and appropriately the effects of policies and strategies on biodiversity alongside other natural capital, social and economic effects.

However, the relationship between biodiversity and ecosystem services is uncertain and complex to measure and value.

For these reasons, biodiversity may be made the subject of a strategic constraint or goal for a policy, programme or project, such as setting:

- options to avoid a net loss of biodiversity as measured by a biodiversity metric
- a target to create or restore a certain quantity of biodiversity rich habitat

Read section 2.8 on the different approaches to valuing biodiversity. For further evidence and guidance on valuation evidence and metrics, check the Biodiversity tab in the ENCA Services Databook.

1.8 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 it can provide. There are various international classifications of these services. For example, check table 6.3 of the UN System of Environmental Economic Accounting

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 as 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 and gas, solar, wind and tidal power
Regulating services	Ecological processes that regulate and reduce pollution and other adverse effects	Air filtration, water regulation, carbon sequestration
Cultural services	Environmental settings that enable cultural interaction and activity	Settings for recreation, education, tourism
Aggregated and bundled services	The benefits provided by nature are not easy to attribute 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

A further category 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. Supporting services are not included as their effect is already captured within the other Databook categories, including the bundled categories.

Negative environmental effects

Alongside ecosystem services, it is important to include negative environmental effects that are typically caused by human activity (as externalities). These include various forms of waste and disamenity, air pollution, noise, soil degradation, invasive species, greenhouse gas emissions and flood damage. These negative externalities can:

- directly affect welfare (for example, exhaust fumes harming the health of pedestrians)
- indirectly affect welfare through the pressures they put on the condition of natural capital (for example, water pollution affecting recreational benefits)
- be partially mitigated by the various regulating services (for example, woodland absorbing air pollutants or reducing flood risk)

Benefits from natural capital assets

The services provided by natural capital provide benefits for individuals or to economic production. 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). It is changes in these benefits which are the focus of valuation in appraisal.

Table 4 shows the difference between the type of ecosystem service or environmental effect and the final welfare effect to be valued.

- Welfare effects are positive where natural capital is enhanced or negative environmental effects reduced.
- Welfare effects are negative where natural capital is lost or negative environmental effects increased.

Read Annex 2 for more detail on environmental benefit and effect categories.

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 and 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
Cultural services	Settings for recreation, education, tourism	Recreation benefits, education benefits, producer surplus, physical and mental health benefits
Aggregated and bundled services	Amenity, biodiversity, landscape, water quality, non-use values	Various use and non-use benefits. There may be trade-offs between different types of benefit
Negative environmental effects	Air pollution, noise, flood damage, soil degradation, greenhouse gas (GHG) emissions	Health costs, damage costs, output losses

Typically, each broad habitat type can provide 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 decide what to focus on.

2. Economic valuation of the environment

2.1 What is economic valuation?

Economic valuation measures how much an asset, product, activity or service is worth in terms of the benefits that are experienced or enjoyed by individuals or organisations.

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, effects or qualities 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 several forms; direct use value, indirect use value, option value and non-use value.

Direct Use Value

This is where individuals make actual or planned use of an ecosystem service:

- consumptive use value refers to the use of resources taken from the ecosystem (for example, food, timber)
- non-consumptive use is the use of nature without taking any elements (such as recreation and landscape amenity)

Indirect Use Value

This is where individuals benefit from ecosystem services rather than directly use them. These tend to be the regulating and supporting services (for example, flood regulation or pollution filtering) and various cultural services (for example, watching nature programmes on television).

Option Value

'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 currently. An example would be a National Park, where people who have no intention to visit it may still be willing to pay something to keep

that option open in the future. It can be thought of as a form 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

'Non-use Value' comes from the knowledge that the natural environment is maintained. It can be based on three different motives:

1. Bequest motives where individuals attach value to the fact that the ecosystem asset will be passed onto future generations (just as they have from previous generations, such as ancient woodland)

2. Altruistic motives where individuals value the availability of the asset to others in the current generation (such as beaches in other parts of the country)

3. Valuing the existence of habitats or species irrespective of any actual or planned use for it, for example by making legacy donations to conservation charities for an endangered species that they will never see

Many people who may hold non-use values in the economic sense, understand nature to be objectively valuable. This can provide the motive for non-use values. Such philosophical and religious perspectives lie outside economic valuation which is necessarily subjective. Instead, economic valuation is concerned in a pragmatic and empirical way with the various benefits that people and society perceive, experience or derive from the natural environment.

Read the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) approach to diverse perspectives of nature's value for more discussion around this.

In general, economic values are based on human preferences which can be driven by the interplay of ethics, culture, incomes, tradition and technology. Although economic values are subjective, they are often measured through objective data and based on biophysical changes and metrics, such as tonnes or visits.

How are environmental effects valued?

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. In 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 you want to estimate. Valuation methods can be broadly divided between 'revealed

preference', 'stated preference', direct 'wellbeing' and cost-based approaches. 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 (check section 2.10).

Check Annex 3 for more detail on the various methods.

2.2 Are there standard environmental values?

Generic or standard values, with uncertainty ranges, 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. In particular, benefits will often vary with local and spatial factors, 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. Valuations can also vary because of different or experimental methodologies, study contexts and datasets.

To make the evidence base tractable, the ENCA Services and Assets Datebooks are selective in the studies that are included. 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.

Economic valuation evidence can be accessed through the ENCA Services Databook and ENCA Assets Databook. Check also section 6.

Crude average ecosystem service values by hectare of broad habitat may be derived from the UK natural capital accounts, based on aggregated service values and overall areas. However, these would be very partial and may not capture the full welfare benefit. Also, regulating and cultural service values are likely to vary widely within national averages. This reflects spatial variations in ecosystems or beneficiary populations. The Services Databook provides a breakdown where possible. The accounts are currently of experimental status and are subject to regular revision.

2.3 Why put a value on the environment?

Economic valuation is not about looking to "sell" or "commodify" nature. It is a useful way of making the relevance and benefits of nature more visible in decision-making.

Valuation can help 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 neglected and exaggerated. For this reason, it may not always clearly support a conservationist approach. For example, the costs of conservation may exceed the possible benefits. In this case, valuation can facilitate debate as to whether there are other unmeasured benefits or considerations that might tip the balance towards environmental protection or enhancement.

Economic valuation of the environment is typically undertaken for one of 2 purposes:

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

This is part of economic appraisal (read section 3).

Environmental valuation is often unavoidable even if not explicit. For example, say an authority chooses not to spend £2 million on a scheme to improve water quality. This decision implies that the marginal improvement in water quality is worth less than £2 million, or at least worth 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 exceed the benefits of an alternative project), in which case an efficiency or welfare gain has been lost.

Valuation of environmental changes can also inform economic instrument design or the estimation of financial liabilities.

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

This is known as natural capital accounting (read section 4). It can provide both annual and capitalised or lifetime values, based on the set of services provided.

Economic valuation can demonstrate the value of a natural capital asset, and identify beneficiary groups. This may in turn generate support for a wider agenda of environmental improvement or prompt a new dialogue within organisations and with stakeholders. For example, a local authority may wish to understand and communicate the value of the services provided by its accessible green and natural spaces.

When accounts are updated, they can assess change in value over time. It does not make sense to put an absolute monetary value on something (such as nature) that we cannot live without. But it can still be valued in a limited way. In the same way, the national housing stock can be valued even though it makes no sense to imagine a society without housing. Similarly, human capital is measured by the Office for National Statistics

(ONS) as the projected lifetime earnings of working age people. However, this ‘human capital’ clearly is not ‘putting a value on human life’ or referencing its intrinsic value and dignity.

For the insight that natural capital valuation can provide at a national scale, review Defra’s paper Nature at Work for People and the Economy: 10 Insights from the UK and England Natural Capital Accounts.

2.4 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:

- values can be positive (the value of ecosystem services), or negative (for example, degradation of natural capital or damage costs of pollution). The reduction of a negative impact is a benefit while the reduction of a positive service is a cost
- monetary values may be expressed in aggregate (for example a million pounds) which can relate to different spatial scales (for example, UK, England or Greater London)
- alternatively, unit values are those expressed in relation to a particular physical metric, such as a pound per hectare, per kilometre, per cubic metre, or per household
- unit values may relate to average values (for example, dividing aggregate woodland values by the total number of hectares) or marginal values (for example what is the additional value of an extra hectare of woodland?)
- be clear what type of unit value is appropriate. The use of average values in cost benefit analysis may be misleading if the focus is on marginal changes, or if the marginal and average values are likely to be quite different
- values may be expressed as annual estimates (pounds per year) or as capitalised, ‘present value’ estimates that reflect an expected flow over many years with a discount rate applied to future values. Do not confuse the two, as they will be measuring different orders of magnitude. For example, the value of parks within a local authority area may be expressed in annual flow terms as providing say £50 million of services per year; or as capital asset value of say £700 million
- benefit values can be combined with measures of cost to provide absolute Net Present Values (NPV) or benefit to 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 in terms of monetised benefits

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 or regional 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).

More guidance on these points is given in the ENCA Services Databook for individual environmental effects.

2.5 Applying valuation evidence to new contexts – value transfer

Environmental valuation is not simply a matter of 'finding a value'. Rather, it is a careful process of applying existing economic valuation evidence 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 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? Be proportionate

2. Identify the population affected. 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 or study. There may be several options. Where different values are provided, 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 2022 or 2023). A GDP Deflator and calculator is 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 how appropriate or robust the favoured estimates are

Read Valuing environmental impacts: guidelines for the use of value transfer for detailed Value Transfer guidance.

2.6 Projecting values into the future

For 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. With Green Book declining discount rates, an accounting life of 100 years captures around 92% of the discounted value of an infinite lifespan.

Costs should be projected for as long as the benefits that depend upon them.

A review of the Green Book in 2021 concluded that future environmental impacts should not have a different discount rate, but issues specific to environment should be reflected in relative price adjustments. A number of factors need to be considered in projecting future values. On the one hand, 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 beneficiaries through population growth
- climate change trends for example, in a growing role for urban cooling services and natural flood management or a rising trend in non-traded carbon prices

Against this, where an intervention increases natural assets, the level of service may take time to increase to its potential. For example, the regulating, provisioning and cultural services from planting new woodlands will increase over time as the woodland matures and grows. Carbon sequestration benefits are also unlikely to be linear.

For some regulating services, the value of the service may decline over time to reflect a projected downward trend in the hazard that is being mitigated. This may apply for example to declining levels of background air pollution over time.

Green Book guidance is that health-related effects (for example, air quality and noise damage) are discounted at a lower rate of 1.5%, because the ‘wealth effect’, or real per capita consumption growth element of the discount rate, is excluded. This is equivalent to a 2% real terms annual uplift in values at a standard discount rate.

Check the ENCA Services Databook for specific guidance by individual service or effect.

2.7 Challenges and limitations of using economic valuation

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, provide appropriate caveats and undertake sensitivity analysis and quality assurance.

The ENCA Services Databook includes assessments of the evidence base for each of the environmental effect categories.

Economic valuation will often be partial, particularly where multiple effects are expected. 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 to 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 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.

However, even a partial valuation can inform discussion as to the trade-offs between monetised and non-monetised effects.

Values will also depend upon the distribution of income, as is the case with all market values. So it is important to understand to whom the estimated benefits accrue and to follow Green Book guidance (Chapter 7).

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 signify real effects on wellbeing, they may not imply actual cash savings or benefits, nor 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, or a constraint on options, may be more appropriate (read the guidance on biodiversity in section 1.7)

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. 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 way of collating, analysing and presenting this diverse data and evidence in the policy process.

Read section 1.4.6 of the UK National Ecosystem Assessment Follow-On Synthesis Report (2014) for more information on the Balance Sheet approach.

The 3 stages reflect the increasing complexity of the environmental context:

- conventional strategic analysis - such as cost to benefit analysis and environmental impact analysis, with increased focus on distributional and equity issues
- regional and local impact analysis - with greater spatial and socio-economic information on winners and losers and potential compensation measures
- 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. These methods can be employed, at the longlist stage of appraisal, to consider non-monetised trade-offs and rank options. They can also inform the design of primary valuation exercises (check section 2.10).

Read Shared, Plural and Cultural Values: A Handbook for Decision Makers (2014) for practical information and examples of when and how shared values other than economic values can be taken into account in decision making.

Incorporating qualitative and quantitative assessments into the decision making and appraisal process ensures that economic valuation evidence represents a ‘witness’ rather than a ‘judge’.

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

2.8 Approaches to valuing biodiversity

As a cross-cutting component of natural capital covering species and habitats, biodiversity is particularly challenging to value.

Direct economic valuation of some welfare effects of biodiversity changes may be possible, such as pollination, amenity, non-use values. (Check the ENCA Services Databook).

An indirect approach to valuing biodiversity gains and losses can be achieved by using the habitats associated with biodiversity as a proxy. Here we value the changes in measurable ecosystem services associated with those habitat changes. This might also be relevant where the objective is a net gain in biodiversity, as measured by a habitat-based biodiversity metric.

This approach to valuing biodiversity effects would still give a partial estimate. Additional to these would be genuine “non-use” values associated with biodiversity such as species diversity, and insurance and resilience values (check Table 3 and section 2.1).

The social costs of biodiversity loss may be judged too difficult to value adequately in appraisal. In this case a target or constraint could be set such that all options must meet that constraint (for example, no net biodiversity loss as measured by a biodiversity metric), and any biodiversity loss is compensated for. With this approach, other ecosystem service values can be included in compensation options to identify the most cost-effective way of meeting the biodiversity constraint or target. If a potential loss of biodiversity is not avoided, it should still be accounted for in appraisal as a social cost. This should be based on the valuation methods above, or at the very least on what it would cost to replace or offset the loss, such as the cost of habitat restoration or market-based biodiversity credit.

For more information on these options, see the Biodiversity Tab of the ENCA Services Databook.

2.9 How robust is your valuation evidence?

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. 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 such as what values are at stake - what is the order of magnitude?

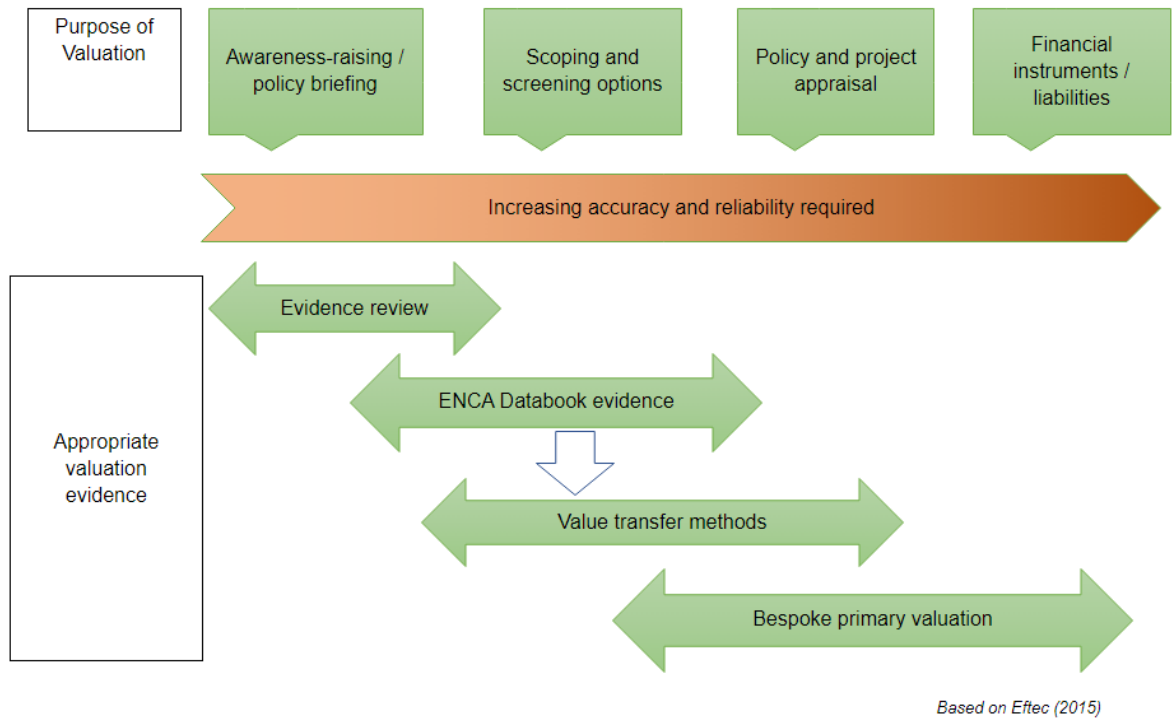
- accounting such as how assets compare and change over time
- scoping and screening such as whether values likely to be significant
- detailed appraisal such as value for money and ranking priorities
- detailed design of economic instruments requiring marginal valuation, or cost recovery approaches and liability calculation (the most precise)

Moving along this spectrum, the required robustness and reliability of the evidence increases. For initial briefing and scoping, ENCA Databook evidence and associated evidence reviews will be enough. For use in appraisal, further value transfer would be needed. A bespoke primary valuation would be necessary where there are significant appraisal or legal needs and the values at stake are substantial (Figure 3).

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. 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.

Figure 3: how robust should valuation evidence be?



2.10 Creating new valuation evidence: primary valuation

Where no relevant valuation study exists and the cost to 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 or modelling. This may take 2 forms:

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

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

The Value transfer guidelines describe what is good practice in designing primary valuation studies (as Annex 2). It 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 refer to 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.

2.11 Quality assurance

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

- is the level of effort proportionate to the purpose?
- have appropriate sources of evidence been used?
- have value transfer principles been adopted?
- where values are partial, is this made explicit? and is qualitative evidence presented to complement partial valuation evidence?
- are assumptions, 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?
- 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)?
- have relevant spatial considerations and variations been considered?
- are distributional effects relevant and considered? Is it clear who the beneficiaries or losers are?
- where multiple services or benefits are included, is there any double counting of the same benefit?
- are quantitative and qualitative assessments that underpin valuation estimates presented clearly?
- is a consistent year adopted as a price basis for different valuations?

Read the HM Treasury's Aqua Book for guidance on analytical quality assurance and addressing analytical uncertainty.

3. 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. In particular paragraphs 8.76 – 8.84 ('Natural environment'). 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).

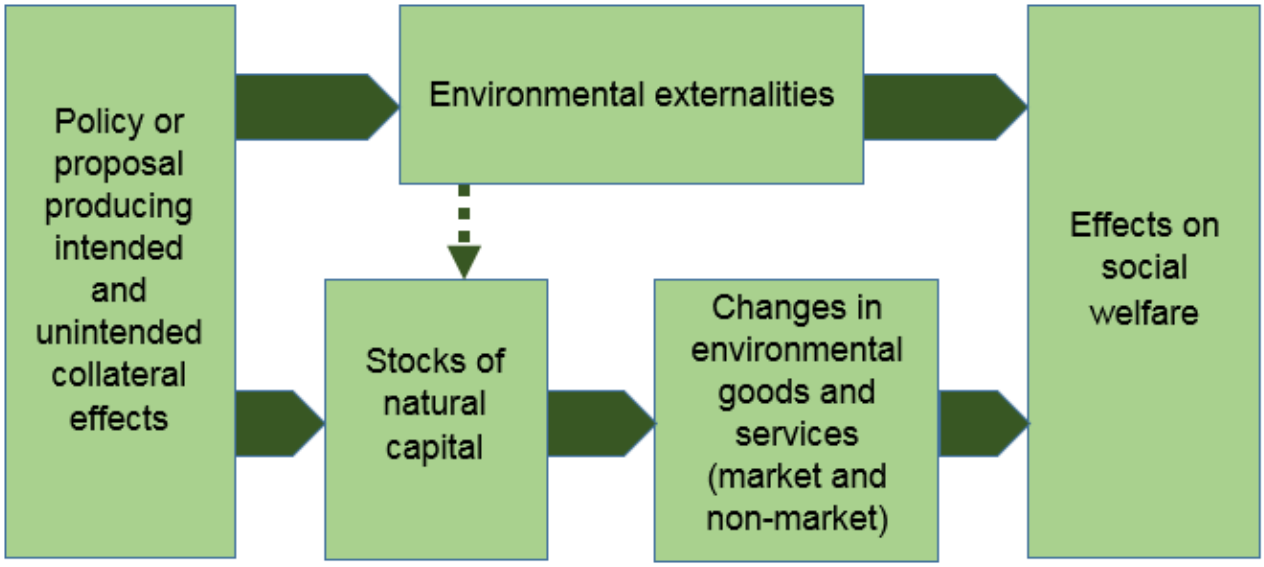
A natural capital approach may be used to support appraisal when considering the environmental principles. Ministers of the Crown, and those developing policy on their behalf, must have due regard to the Environmental principles policy statement when making policy. The policy statement explains how to interpret and proportionately apply the principles that will contribute to the improvement of environmental protection and sustainable development. The 5 principles are: integration, prevention, rectification at source, polluter pays, and the precautionary principle.

Figure 4 provides a simple representation of how policies or proposals may affect stocks of natural capital directly and in turn affect social welfare.

It also shows the direct effect of 'traditional' environmental externalities such as air and water pollution (described in ENCA as 'negative environmental effects') on welfare. These externalities will also adversely affect natural capital stocks (dashed arrow), so there are indirect effects on welfare through degradation of natural capital.

This enables a more comprehensive appraisal, one that considers impact both on the stocks of natural capital and on the benefits that it provides, as well as the potential for nature to support a range of policy goals (section 3.2).

Figure 4: Natural capital 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 in principle justify government intervention.

Public goods

Many services provided by natural assets are not supplied through markets. This is because they are non-excludable in supply (available to all) and, once provided, non-rivalrous in demand (it matters little how many people enjoy them). For example, climate regulation and the ability of vegetation to absorb air pollution benefits whole populations.

Natural assets are often public goods within a region or locality. 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 and 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 occur when an activity imposes costs for economic agents that are not directly involved.

These tend to result in inefficiently high levels of resource depletion, pollution and damage.

Examples are pollution of watercourses, biodiversity loss, excessive land-use conversion, and depletion of peat bogs. Where natural assets have been depleted beyond economically 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 can improve decision-makers' understanding, so as to make better informed decisions.

Equity considerations

Disparities in natural capital or its benefits to different demographic or socio-economic groups or regions may provide additional justification for intervention.

3.2 Meet your policy goals with natural capital options

Where enhancing or protecting natural capital is the object of policy or spending (for example, a programme of habitat creation or restoration), the standard Green Book approach to identifying a range of options applies.

Many public sector bodies impact or rely on natural capital. So natural capital can also support shared outcomes across policy areas and, as stated in the Green Book, nature investment can be used to 'meet broader policy goals'.''. This is relevant at the long list stage in Option Appraisal. Table 6 provides examples although these are not exhaustive.

This stage can support application of the integration principle when considering the Environmental principles policy statement. You may also want to consider opportunities for your policy or investment to protect, maintain, restore, or enhance the environment.

The ENCA Natural Capital Assessment template includes further guidance on nature-based options.

Annex 1 links the policy goals in Table 5 to other sections of the ENCA resource.

Table 5: how nature-based approaches can support policy goals

Policy area or goal	How natural capital can contribute
Physical health	Nature-based recreation (various habitats) Settings for walking and cycling routes Reducing air pollution
Mental health	Nature-based recreation for different ages Mitigation of road traffic noise Incorporating views of greenspace from homes, schools, hospitals, workplaces Nature volunteering and green prescriptions
Local economic development	Nature-based tourism and outdoor leisure Green space amenity in workplaces and settings for business locations 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 Making high streets more attractive and climate resilient Mitigation of pollution pressures from new development Streamlined approaches to biodiversity net gain

Policy area or goal	How natural capital can contribute
Net zero emissions	Woodland creation Peatland restoration Saltmarsh creation Grassland restoration
Climate resilience	Natural flood management approaches Sustainable urban drainage schemes Cooling effect of vegetation in cities Habitat restoration
Transport	Settings for cycling and walking Supporting resilience Mitigating pollution and noise Ecological corridors
Education	Settings for outdoor learning Support for ecological knowledge and specialist qualifications Enhancing nature within school grounds
Levelling up	Addressing regional deficits in accessible natural greenspace
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 underpinned or surrounded by natural capital

3.3 Screening for effects on natural capital

Consistent with the principle of proportionality, use the Green Book screening questions to consider the possibility of unintended consequences on, or missed opportunities for, natural capital. Table 5 provides more detail and guidance and is included in the ENCA Natural Capital Assessment template. You can record your answers (yes / no / possibly) and reasoning on the template.

Table 6: screening for natural capital impacts

Screening question	Guidance
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, development, use or appearance 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 greenhouse gas 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. Water quality can be affected by changes in point source pollution from specific industrial locations, or changes in diffuse pollution from a variety of sources such as transport routes, agriculture or housing.
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 (for example, because of building development but also by disrupting or creating connections between sites caused by changes in transport systems or tourist activities.
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. Changes in the quantity, quality or access of such sites can have significant welfare effects.
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

The screening questions may be helpful when Ministers of the Crown, and those developing policy on their behalf, are applying the duty to have due regard to the Environmental principles policy statement when making policy. The questions can help establish if a policy has potential environmental effects (positive or negative).

The questions relate to different aspects of the natural capital framework. Give adequate thought to each question, particularly effects which may not be immediate or direct. Direct or indirect impacts on nature may arise, for example, from a policy or investment's effects on:

- supply chains and manufacturing processes
- waste products or secondary products, and changes in resource efficiency
- transport, building or infrastructure
- consumer behaviour.

Effects can be positive as well as negative. Expert advice or research may be required. Only say 'No' if you have sufficient reason or evidence for doing so.

3.4 Guidance on proportionate assessment

Further assessment, based on the 4-step natural capital framework (see section 3.5) is recommended where:

- you have answered "yes" to at least one question

- you have answered “possibly” to the first question on land or at least two questions

Judging how much further assessment is proportionate will involve a number of considerations:

- The absence of environmental impacts should not be assumed. If you think a natural capital assessment is not needed, you should be transparent and set out why no substantive environmental impacts are likely
- Whether the Environmental Principles apply
- Materiality – whether the process or result of doing a detailed assessment might lead to a material change in the options or choice between them
- Second round and very indirect effects on the environment, for example, arising from long-term behavioural change, can be difficult to assess quantitatively. It may be sufficient to identify and describe them in a qualitative way
- 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, these effects are often linked with other effects on natural capital, so it is important that all effects are accounted for
- Where appropriate and proportionate, significant overseas environmental effects should also be identified and assessed

Where it may not be proportionate to do a full natural capital assessment, the 4-step process below can still be used in a light-touch way to develop, cross-check or clarify responses to the screening questions.

In addition to assessing for natural capital effects, an appraisal should also consider the potential effects of climate risks and trends and consider adaptation measures in response to these. See supplementary Green Book guidance on Accounting for the Effects of Climate Change.

3.5 Assessing natural capital effects using the 4-step approach

You should adopt a 4-step impact pathway approach to assessment where nature-based options are shortlisted or where the screening questions suggest potential environment effects. This is summarised in Chapter 8 of the Green Book.

Like any assessment, this can be done to different degrees of detail, depending upon the scope, significance and materiality of the potential impacts. What is crucial is that each step is properly considered, and relevant evidence in ENCA consulted, rather than assuming that no meaningful assessment can be made.

This approach assesses how a proposal may affect natural assets, what this means for welfare and whether effects can be valued. Each step is described below with additional guidance.

The ENCA Natural Capital Assessment template 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.

The 4-step approach may be helpful for Ministers of the Crown, and people developing policy to make sure that they have due regard to the Environment principles policy statement. It can help summarise the potential environmental effects of a policy, whether positive or negative.

Step 1: understand the environmental context to the proposal

The first step is to understand the relevant natural systems that may be affected or contribute to outcomes and the environmental and geographic context of the proposal. This also helps establish a baseline against which positive or negative effects can be assessed. The typology of 'broad habitats' set out in Section 1 offers a starting 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.

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, 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.

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 (check Table 2)) might specifically be affected
- consider the spatial nature and scale of effects - these may be localised or widespread.
- decide whether these effects represent risks or opportunities - are they modest or significant?
- consider the likely time frame 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 (See Step 4).

Each of the broad habitat tabs in the ENCA Assets Databook lists relevant ecosystem services and effects that might be affected. Evidence on specific ecosystem services and environmental effects can be found in the ENCA Services Databook.

Step 3: consider and value the welfare implications

How will changes to assets (identified in Step 2) affect benefits provided to society by natural capital?

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. Care should be taken to avoid double counting where impacts overlap.

The range of potential impacts include direct or indirect effects on the various services and benefits set out in Section 1.

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.

Do not assume that monetization of effects is impossible. The ENCA Services Databook can be reviewed for relevant valuation evidence, guidance and sources appropriate for identified effects.

See Section 2 of this guidance for further detail on undertaking economic valuation.

When there are quantified but unmonetized ecosystem services, consider doing a break-even analysis - what would the unit value of the service have to be in order for net benefits to be positive? In some cases, it may be possible to identify trade-offs between different costs and non-monetised impacts of different options.

Effects and factors that cannot be given a monetary value should be quantified or, if that is not possible, accurately described in qualitative terms. Quantification and qualitative description should focus on effects that contribute to changes in human welfare.

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 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 gaps in your knowledge and evidence that need 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 2.6).

The template includes a section for you to summarise the insights of the 4-step assessment.

3.6 Monitoring and evaluation with natural capital in mind

According to the Magenta Book, evaluation involves understanding how an intervention has been, or is being implemented and what effects it has, for whom and why.

Evaluation can inform thinking before, during and after the implementation of an intervention, identifying what can be improved. The environmental risks, opportunities, costs, benefits and uncertainties identified at the appraisal stage should inform evaluation thinking.

The 4-step process and valuation of ecosystem service effects can provide the basis for a Theory of Change. This identifies how an intervention is expected to bring about change, the anticipated final benefits, the associated risks and assumptions and the importance of context in delivering final benefits.

The emphasis on data within a natural capital approach may enhance evaluation, by helping to ensure monitoring and data collection are given greater priority. Data may then be available to evaluation which would not otherwise have been the case. The spatial nature of natural capital effects is another important consideration for monitoring and evaluation.

Consider using the Environmental Indicator Framework for the 25 Year Environment Plan as a starting point for potential metrics. Many of the indicators are referenced in the ENCA Databooks according to the relevant service or asset. 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 to interpret changes in accounts and the factors that are driving those changes.

The potential for significant natural capital effects, whether intended or not, should inform data collection and planning of process evaluation and impact evaluation. Value for money evaluation based on actual changes can be useful although a full understanding of outcomes and impacts will also typically require other metrics and qualitative evidence.

Issues and interventions which have links to the natural environment are often of a 'complex' nature that require innovative monitoring and evaluation methods. Read the supplementary guidance to the Magenta Book (PDF) for guidance on tackling this challenge.

4. An introduction to natural capital accounting

Natural capital accounting is the attempt to bring a systematic, standardised and repeatable framework to recording information on natural capital and the services it provides, whether or not those services have a market value.

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. It can be done at national, regional, local or organisational level.

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. 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 or experienced within an accounting period, usually a year.

Accounts should be based on spatially disaggregated data where possible, although this is challenging particularly at larger scales. Accounting seeks to answer a number of key questions in an integrated and systematic way, through the production of interrelated accounts (Figure 5):

1. what are the assets we own, manage or have responsibility for?
2. what condition are they in?
3. what services do they provide?
4. what is the value of those services now?
5. what is the expected value of those services into the future?

In addition, at corporate or more granular spatial scales, it is often appropriate to include a further component:

1. What are the costs of maintaining the assets?

For further guidance on the first 5 types of accounts listed above, read the Principles of Natural Capital Accounting produced by the Office for National Statistics and Defra.

The Natural Capital Committee originally developed and tested guidance on Corporate Natural Capital Accounting. Building on this and other practical experience of accounting, the British Standards Institution has issued a Natural Capital Accounting Standard which

provides specifications and principles for the preparation of natural capital accounts by organisations.

Figure 5: the scope of natural capital accounts

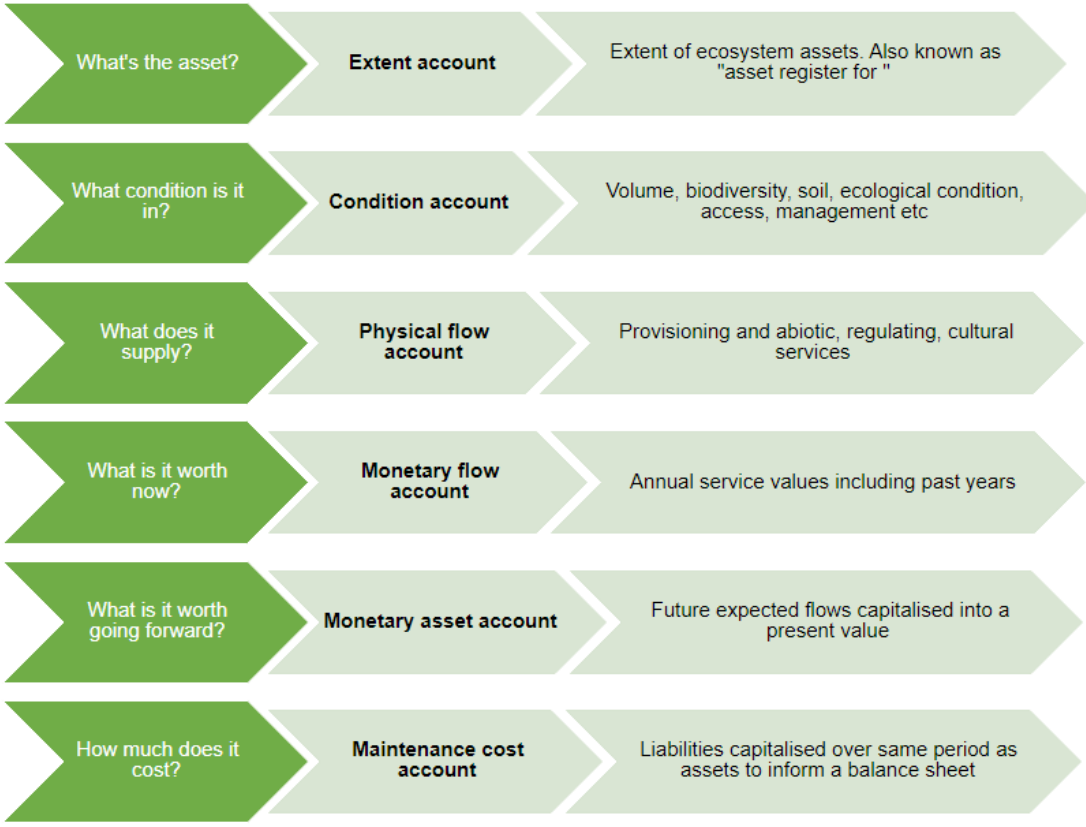


Table 7: essential and desirable features of natural capital accounting

Feature	Essential	Desirable
Accounts for annual flows in physical and monetary terms	x	
Time-series for service flows	x	
Assessing the state and contribution of the ecosystem	x	
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
Integrated into management reporting processes		x

4.1 Distinction from appraisal

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 to benefit analysis or one off natural capital assessments that are not repeated.

Table 8 summarises the key conceptual differences between accounting for natural capital and economic appraisal.

Table 8: comparison of accounting and appraisal

Differences	Accounting for natural capital	Appraisal (Cost to Benefit Analysis)
Scope and focus	Understanding the state of the current stock of assets and what they currently provide. Aims to be comprehensive.	A specific 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 and subsequent appraisal exercises	Tends to a more operational context for assessing specific priorities. Will be a one-off piece of analysis for a particular decision.
Which aspects of the environment are valued?	Focused on what nature provides but aims to be comprehensive. Valuation should seek to value the ecosystem service (for example, the contribution of the ecosystem to farming, rather than the output of farming itself). Negative environmental impacts 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 as they monitor trends and 'actuals'. 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	Natural accounts are 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, particularly at local or corporate level. Accounts 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 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	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. The core UK accounts do not include cost information.	An essential part of appraisal these can include environmental as well as other types of costs
Role of Net Present Value and discounting	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.

4.2 What are the benefits of natural capital accounting?

A range of information from disparate data sources about natural assets, their condition and the services they provide.

Natural capital accounting is not itself a decision-making tool, but the process of compilation and the integrated information it provides can provide a strategic overview of the state and value of natural assets. In particular, accounts can:

- raise awareness of the importance of natural assets

- identify an organisation's dependencies on natural capital and risks and opportunities arising from investing in nature
- provide a baseline for a natural capital plan (Check section 5) and so identify priorities for investment
- 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
- highlight key trends over time (as accounts are repeated)
- provide a means of monitoring outcomes of strategies to make better use of natural capital, to support target setting and encourage greater accountability
- generate physical and monetary indicators which may be derived directly from the accounts in combination with other socio-economic information
- 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
- facilitate accountability and transparency with stakeholders relating to the benefit and funding of natural capital assets

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

- enable aggregation and comparison of ecosystem services and ecosystems and at national level, can be compared and potentially 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)
- demonstrate that natural assets are not simply a financial liability or a constraint, but offer real value to people and the economy (for example, for every £1 spent, the asset generates a minimum of pounds of benefit per service)
- provide a base for scenario analysis, in which different forward projections of service flow can generate different estimates of net present value and to inform business cases for specific investments in natural capital
- identify who benefits from ecosystem services and by how much

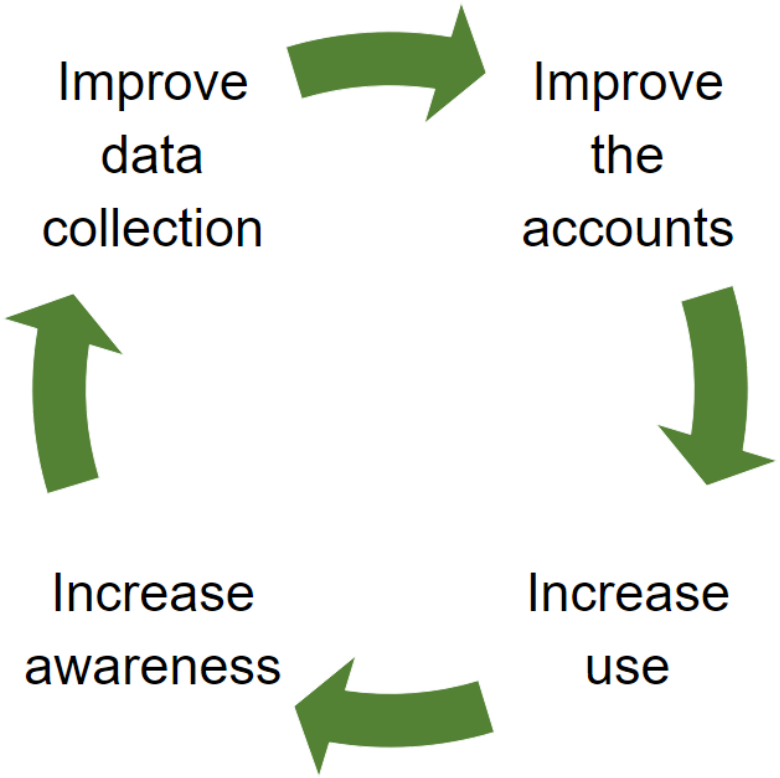
For use of valuation in accounting, check Defra's paper Nature at Work for People and the Economy: 10 Insights from the UK and England Natural Capital Accounts and sub-national applications in ENCA Case Studies.

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

- development of policy relevant indicators, linking data with different sources, for example, financial and socio-economic information
- a basis for analysis and economic modelling and 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. This in turn increases awareness and interest in improving data collection and methods and filling gaps, leading to a virtuous circle.

Figure 6: the virtuous circle of accounting



4.3 Developing an account in practice

There are a number of considerations that enable development of an account in practice:

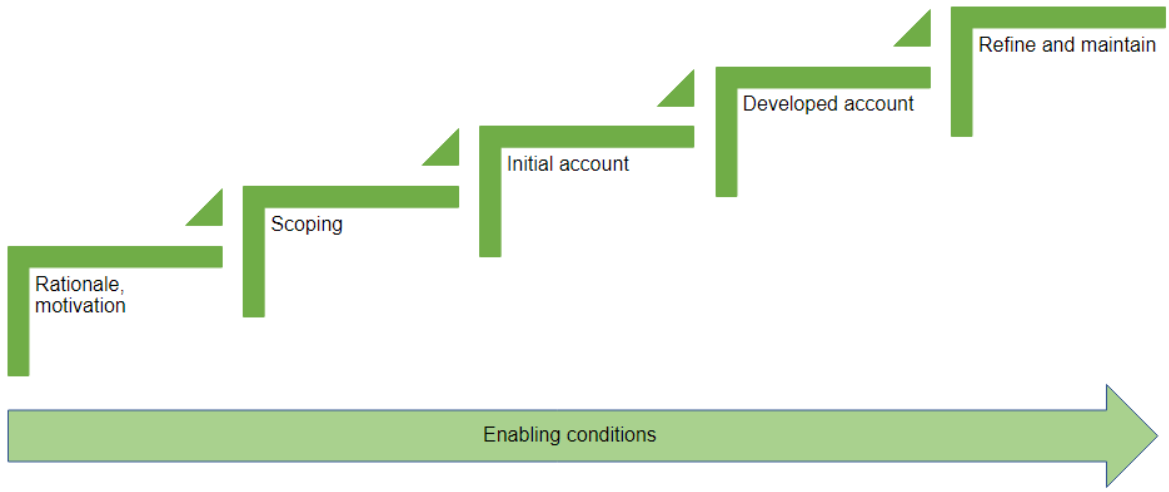
- start somewhere, but provide sufficient resources - baseline studies are often a good starting point, but the key is having capacity to maintain and develop accounts over time

- compilers should be open to a wide range of existing and new sources of information - the ENCA Databooks reference many potential sources, and check also section 5.1 below for place-based accounting
- consistent methods and a clear and transparent framework provide a starting point, based where necessary on pragmatic conventions and existing standards and principles
- 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 manage expectations

It can be useful to think of the development of an account over a number of stages (Figure 7):

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

Figure 7: the stages in developing a natural capital account



Natural capital accounting at different spatial scales

There is considerable overlap between national, corporate and local approaches to natural capital accounting, as reflected in 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 the experimental nature of natural capital accounting, including what is valued and how it is valued.

Table 9 compares accounting at different spatial scales. The latest national accounts are all referenced in the ENCA Assets Databook. Examples of sub-national natural capital accounts can be found in ENCA Case Studies.

Table 9: 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 and the UN System of Economic Environmental Accounting. Based on conceptual architecture of the System of National Accounts	BSI Natural Capital Accounting	Draws on both national and corporate guidance
Treatment of asset extent and condition	Done by broad habitat categories. Currently limited spatial disaggregation. Several categories of asset condition each with a number of characteristics or indicators that are relevant to the range of services.	Extent defined according to land ownership, management or influence. Assets may be categorised at a finer scale than broad habitats, for example, components of ecosystems. Typically combined into a single ‘Asset Register’.	Assets may be accounted for at a finer scale. Typically combined into a single ‘Asset Register’. Biophysical, economic and spatial data should have a 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. A service flow implies a real or notional exchange between ecosystem and user. This value may not be the same as a welfare value. This produces a supply to 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. Although exchange values may still be relevant. Beneficiaries may be grouped, for example, businesses, households, public sector.

4.4 Use of economic valuation in natural capital accounting

There are 2 forms 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 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’ such as capitalised value.

The projection will reflect expected trends in the physical flow and trends in real value or price of that flow.

Use of exchange values in accounting

Monetary valuation provides a common metric through which services can be aggregated, compared and comparisons made at national level 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’).

Housing, for example, can be assigned 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 because society cannot do without housing. The same principle can be applied to ecosystem goods and services.

For some services, exchange values are likely to be a lot smaller than welfare values.

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.’ Check section 6 of (ONS and Defra Natural Capital’s Accounting Principles). This implies the need to impute an exchange value.

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. However, in these cases 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.

In terms of valuing non-market services on the basis of exchange values, resource rent and production function approaches, avoided or replacement costs and hedonic approaches are generally favoured from the perspective of national accounting principles.

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

For further guidance on exchange values and methods, read chapter 9 of UN SEEA Ecosystem Accounting (PDF).

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 and 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 to identify trends

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.

Valuation of ecosystem services and assets in accounting faces several challenges:

- The representation of natural capital in monetary accounts will only ever be partial
- Valuation estimates may only be indicative, yet accounts rely on “single point estimates”. 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
- Applying standard and recognised methods. Check ONS’s Natural Capital Accounting Principles, and latest guidance by UN SEEA
- Natural assets are interrelated and complex, subject to biophysical uncertainties (flood regulation), spatial variations (recreation, air filtration), environmental limits and thresholds. Science is needed to understand these relationships and interpret the results
- Valuation needs to be considered alongside other biophysical information about the assets, 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 should in principle reflect both the current and expected future condition of an asset

- Even a reasonably comprehensive set of natural capital accounts will have limitations

Firstly, they focus only on what nature provides (although some human pressures will appear in the condition account). They would not value the full range of environmental impacts and externalities imposed by human activities. It may be relevant to report on these separately (as proposed in the BSI Natural Capital Accounting Standard), 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, because asset values reflect a range of other factors, or a condition account lacks an aggregate metric. To address these challenges, UN SEEA Ecosystem Accounting gives guidance on decomposing changes in asset values (chapter 10) and ways of deriving composite ecosystem condition indices (chapter 5).

5. Place-based natural capital approaches

5.1 Practical guidance on natural capital planning

Several practical guides have been developed since the publication of the UK NEA in 2011 to support a systematic and strategic natural capital or ecosystems approach or 'plan' at a local or landscape scale. This is an evolving area that can involve elements of appraisal, accounting and valuation.

This section summarises the latest guidance that has evolved from experience and is practised by Natural England and the Environment Agency. Check Natural England's Natural Capital Evidence Handbook: to support place-based planning and decision-making together with a range of applications and supporting tools and evidence.

The guidance is set out in 6 stages or principles. These principles are being adopted in various spatial and institutional contexts. Read ENCA Case Studies for a variety of applications of local and regional natural capital approaches.

1. Define partnership and vision

There are many circumstances where individuals and groups might want to use a natural capital approach to protect and improve the environment. Meaningful collaboration with a wide range of partners and stakeholders throughout the entire process is key. The partnership should aim to agree a high-level natural capital vision for your place and define its scale and boundaries.

2. Establish a shared evidence base

A key challenge is getting stakeholders on the same page and understanding the current state of natural capital, known as the baseline. There is likely to be a wealth of evidence, knowledge and understanding held by partners to draw on. This stage involves:

- understanding and collating evidence about the place within which the natural capital sits
- measuring and analysing the natural assets within scope, their quantity, quality and location, identifying the ecosystem services and social benefits they provide and who benefits

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

3. Forecast and understand drivers of change

Consider how long-term drivers of change (for example, climatic, economic, demographic) may affect natural capital and the ecosystem services it provides.

- How might these drivers affect the extent, location and quality identified at Stage 2?
- How can these be managed or reduced and what opportunities do they present?

If a natural capital account is developed, these drivers can inform selection of pressure indicators or a risk register and can inform future projections of ecosystem services on which an asset valuation is based.

4. Decide and plan for multiple benefits

Drawing together the previous stages, formulate a plan of action that is more than the sum of its parts, identifying priorities and how potential barriers may be overcome. This stage can involve opportunity mapping (in which the Natural Capital Atlas Maps can provide a good starting point), appraisal (check section 3), modelling, use of tools, scenario development and deliberative discussions to agree a preferred plan and options.

Consider potential innovative funding approaches. Where new funding is sought from private investors or public bodies, a business case may be necessary to demonstrate value for money (check section 2).

5. Make it happen

Actions might be delivered through a wide range of mechanisms, by a number of partners and using various funding sources. This is where economic valuation of environmental benefit can be important. All of these need to be specified and ideally embedded in relevant local strategies and plans. This is one reason taking partners and stakeholders through the whole process together is critical.

6. Check and Improve: evaluation and monitoring

Build in evaluation and monitoring at the outset, when establishing the partnership, vision and goals. This enables the collection of the right data throughout based on clearly defined objectives that are measurable and a ‘Theory of Change’ that identifies key assumptions and risks. Monitoring and evaluation should be proportionate and realistic with the aim of feeding back lessons and providing evidence for future decision making and funding.

Read the Magenta Book for guidance on the main evaluation principles and methods.

5.2 How to make 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 word ‘tools’ is used loosely to refer to methodologies, approaches and resources that support decision making. This can be a source of confusion.

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.

Tools for assessing and exploring natural capital can be divided into 3 categories:

- mapping natural capital stocks (habitat and land use surveys, mapping ecological networks for wildlife or assessing the condition of ecosystems)
- quantifying ecosystem service flows (simple scoring tools, process-based and rule-based spatial modelling, calculation of biodiversity or environmental net gain, 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.

Many of these 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. Defra has funded an update and extension of the Tool Assessor to support ENCA.

Certain tools that are developed or supported by the 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 - 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. Who has quality assured or approved the tool?
- 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? 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.

Mapping natural capital

Geographic Information Systems (GIS) are increasingly important in communicating, assessing and informing decisions on natural capital. Much geospatial data is open source and available as individual spatial data layers. Read the Ordnance Survey's guide to GIS software on their website.

Increasingly such data has been used to develop combined thematic base maps and mapping tools that users can interact with and model changes including economic valuation of certain ecosystem services. Specialist GIS expertise is useful but not always necessary. Open source and proprietary mapping packages are available.

- Defra group have put in place a searchable Data Services Platform to make environmental data openly available to a wide range of users
- Natural England's Natural Capital Atlas Maps and associated data packages can provide users with a starting point for understanding the natural capital in a particular region
- Defra and Natural England have developed an England-wide Green Infrastructure mapping tool, bringing together around 50 sources of environmental and socio-economic data. It provides an England-level baseline and assists local authorities

and other stakeholders to assess green infrastructure provision against the new national Green Infrastructure Standards.

- Ecosystems Knowledge Network's Tool Assessor includes tools that map ecosystem services
- spatial datasets and tools relevant to particular broad habitats or benefit categories are referenced in the ENCA Databooks in the appropriate place
- The Government's Natural Capital and Ecosystem Assessment (NCEA) is a new science innovation and transformation programme, which spans across land and water environments. It has been set up to collect data on the extent, condition and change over time of England's ecosystems and natural capital. For more information, see Mapping our natural assets: the Natural Capital and Ecosystem Assessment programme.

5.3 Applying natural capital in urban and planning contexts – green infrastructure

In local planning and urban contexts, 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' existed as a concept before natural capital and is formally defined in the National Planning Policy Framework (December 2024) as:

'A network of multi-functional green and blue spaces and other natural features, urban and rural, which is capable of delivering a wide range of environmental, economic, health and wellbeing benefits for nature, climate, local and wider communities and prosperity.'

Green infrastructure 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, green bridges, field margins, cycling routes, pedestrian paths and rights of way
- street trees, allotments, community gardens, city farms, vegetated sustainable drainage systems, green walls and roofs, cemeteries and churchyards

The National Green Infrastructure Framework states that good quality green infrastructure "can be seen as a collection of connected natural capital assets managed to provide ecosystem services and benefits for people and nature" which "can help grow the natural capital of city regions, rural-urban fringe (including Green Belts) and rural areas."

The Green Infrastructure Framework provides common principles, standards and metrics, including the mapping tool. Local authorities, developers and communities can use these to plan, design and maintain green infrastructure in an evidence-based, consistent and effective way.

A local natural capital account can support a strategic approach to green infrastructure by identifying, clarifying and measuring the existing state of green and blue infrastructure assets and the services that they provide.

Natural capital and net gain

As noted in section 1.7, biodiversity is a core component of natural capital on which a range of services typically depend.

In a land use development context, the Biodiversity Metric enables measurement of biodiversity losses and gains from a development to support demonstration of biodiversity net gain.

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.

In some cases it may be possible to value the increase in ecosystems services from the creation or change in habitat as part of securing a biodiversity gain. The method would be:

- Estimate the change in habitats associated with the change in biodiversity.
- Then value the changes in ecosystem services associated with those habitat changes.

This might be relevant where an option or objective is a net gain in biodiversity, as measured by the biodiversity metric. This approach to valuing biodiversity effects would give a lower bound as it would not include "non-use" values associated with biodiversity such as species diversity.

Natural England's 'Environmental Benefits from Nature' tool can be used to make an initial non-monetary assessment of gains and losses in ecosystem services along with biodiversity net gain. This can form part of a site based environmental net gain assessment. The tool does not consider indirect pressures on natural capital, such as impacts of emissions of air pollutants from a road scheme. These would be assessed separately.

Other net gain assessment metrics being developed include the Nature Assessment Tool for Urban and Rural Environments featured on the EKN Tool Assessor.

5.4 How natural capital can support local economic development

Green infrastructure can help a number of local development goals, according to the Ministry of Housing, Communities and Local Government, by:

- helping to create high quality environments which are attractive to businesses and investors
- enhancing the built environment, reinforcing local landscape character and contributing to a sense of place
- promoting healthy and safe communities
- providing resilience to extreme climate events and supporting urban cooling, sustainable drainage, and natural flood management.

The ENCA Databooks reference a range of evidence showing how investment in the quantity and quality of natural capital or green and blue infrastructure can support local economic development and productivity:

- Publicly accessible green space supports physical and mental health, and social capital. Siting green spaces near to workplaces supports the mental and physical health of workers
- Natural flood risk management and 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 less-polluting forms of travel. Provision of publicly 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 and the same is true in a less direct sense of regional and local branding

- Enhancement of green infrastructure, including provision of green space and nature -based enhancement of grey infrastructure, can give places the opportunity to grow and support economies of agglomeration

The Environment Agency has developed the 6 stage approach (check section 5.1) into a Natural Capital Guide for the Development Sector, which is aimed at local organisations with an interest in natural capital and economic development, such as local authorities, combined authorities, Local Enterprise Partnerships and Local Nature Partnerships.

5.5 Generate new income streams using the natural capital approach

Services provided by natural capital provide benefits for individuals or to economic production. Some of these services have the potential to generate cost savings or commercial benefits which can, in principle, generate financial returns.

For example:

- water utilities benefit from good farming practices upstream to maintain raw water quality, or sustainable drainage schemes that reduce pressure on drainage capacity
- 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
- local tourism businesses benefiting from well-maintained green and blue infrastructure

New approaches have been developed to value natural capital benefits, and encourage funding for the protection and enhancement of the underlying natural capital assets. These approaches include payments for ecosystem services, market-based approaches and investment models, such as:

- direct payments based on the value of ecosystem service outcomes produced from natural interventions
- supplying demand from compliance markets for mitigation and voluntary offsetting mechanisms focused on particular habitats or species, such as requirements for biodiversity net gain and nutrient neutrality
- investments in sustainable enterprise models that directly benefit natural capital and biodiversity (even if they are not a core objective of the business)

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.

Investment into delivering net zero, climate resilience and nature positive outcomes (i.e. 'green finance') is of increasing interest to the finance sector, with various taxonomies and frameworks being developed. Understanding nature better provides an opportunity for investment and as a way to manage current and future investment risks. For an introduction, read Demystifying Green Finance on the Valuing Nature Network website.

The UK government has set a goal of mobilising at least £500 million a year of private finance into nature's recovery by 2027 in England, and more than £1 billion a year by 2030. To support this, a nature markets framework sets out core principles for the design, development and operation of such markets.

The Financing Nature Recovery coalition has developed roadmap for unlocking private finance investment in nature recovery across the UK.

The main resources include:

- A Community of Practice to share the learning from projects funded by Defra and Environment Agency's Natural Environment Investment Readiness Fund (NEIRF)
- Ecosystems Knowledge Network Nature Finance Learning Hub
- Green Finance Institute, Investment Readiness Toolkit based on learnings from nature-based projects across the UK
- Green Finance Institute, Case studies for nature-based deals and funds in which private capital has played a role, Revenues for Nature toolkits and resources and case studies from the NEIRF
- Payments for Ecosystem Services best practice guide which provides a practical 5-step guidance for those wanting to design and develop payments for ecosystem service schemes.
- Taskforce on Nature-related Financial Disclosures (TNFD) Recommendations
- BSI Flex Overarching Principles and Framework, a standard which outlines requirements for the design and operation of high-integrity nature schemes.

Read ENCA Case Studies and ENCA Assets Databook for further real world examples, initiatives and market-related tools.

5.6 Lessons learnt from local application of natural capital

Application of natural capital approaches at a local level is developing.

Research for the Oxford-Cambridge Arc shows growing interest in the potential for a natural capital approach to inform planning policy and the growth agenda at regional, county, neighbourhood and site scales. The natural capital approach supports more informed decision-making around site selection, site designations, and the development of new natural capital / environmental planning policies.

The ENCA Case Studies include many other applications of natural capital and ecosystem service thinking in various spatial contexts.

Generally, research for Defra of the benefits and challenges of applying a natural capital approach at local level 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 acting
- 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
- 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 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
- 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 originally established by the UK Government, is a leading UK forum for sharing practical learning and resources on place-based natural capital approaches. It brings over 3000 people from across sectors

including the built environment, local government, financial services, nature conservation, health and economics.

6. Finding data and evidence for natural capital approaches

The evidence base on natural capital is vast, complex and rapidly expanding. This can make it difficult for analysts to determine what might be suitable for use in value transfer and natural capital applications.

ENCA has been developed to address this challenge in a pragmatic way. It recognises that much of the existing evidence base does not neatly fit into the natural capital framework and cuts across categories.

In identifying relevant Databook content for a range of users, Defra's Environment Science and Analysis Division has drawn on its knowledge of the evidence base and the expertise of the Defra network.

The 2 Databooks provide a lot of selected references, metrics, guidance and physical and valuation metrics across a wide range of environmental effects and asset categories. ENCA only covers valuation evidence from within the UK. International economic valuation evidence has been recently updated and collated in the UK funded Ecosystem Services Valuation Database.

6.1 ENCA Services Databook

This Databook enables you quickly to investigate key sources for specific environmental impacts, with indicative values where appropriate, alongside selected biophysical metrics and sources. 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.

The Databook collates the most nationally relevant and up to date sources, studies and key estimates for 25 categories of environmental service or effect as set out in Annex 2. It also provides a conceptual overview of each effect and relevant analytical guidance.

The Databook is not exhaustive. You may have available more specific or relevant evidence for your 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.

The detailed notes within each tab can help you use valuation evidence appropriately. But you should also view the original sources to check that you are applying the original

estimates in an appropriate manner. You should cite the original source or study in your work alongside any reference to the ENCA Databook.

6.2 ENCA Assets Databook

This assets databook collates and summarises selected studies relevant for specific broad habitats. Rather than directly report specific numbers, it provides annotated references to:

- relevant UK Natural Capital Accounts for each broad habitat
- relevant 25 year Environment Plan Outcome Indicators, based on the natural capital framework
- selected biophysical data, evidence and tools by habitat
- selected valuation tools and evidence by habitat
- market-related tools

This Databook complements the ENCA Services Databook. Some evidence references are common to both Databooks, but many references are unique to each. To make effective use of the evidence, you should be aware of the principles of valuation and natural capital set out in section 2 of this guidance.

You should cite the original source or study in your work alongside any reference to the ENCA Assets Databook.

7. Annex 1: navigating ENCA by theme

Tables 10, 11 and 12 identify the potential relevance of natural capital to a range of topical and policy themes and relevant resources within ENCA.

Neither the themes nor the suggested pointers are exhaustive but they are included as starting points for further exploration around how natural capital approaches can be applied in different contexts.

Table 10: relevant ENCA resources for various topical and policy themes

Theme	Physical health	Mental health	Local economic development	Housing and place-making
How natural capital can contribute	Nature-based recreation Settings for physical exercise, walking, cycling Removing air pollution Green prescriptions Nature amenity around hospitals	Nature-based recreation for different ages Nature volunteering Green prescriptions Nature views from schools, hospitals Traffic noise mitigation	Provisioning services Nature-based tourism and leisure Workplace nature amenity Temperature and pollution regulation	Sense of place and new recreational opportunities Mitigate pollution pressures from new development Compensate for biodiversity loss
Relevant Tabs in Services Databook	Recreation Physical health Recreation Amenity Air pollution removal	Recreation Noise mitigation Amenity Volunteering Mental health	Provisioning tabs Recreation Landscape Amenity Temperature regulation Water quality Soil	Amenity Landscape Recreation
Relevant Tabs in Assets Databook	Various	Urban Woodland	Farmland Woodland Marine Mountain, Moor and Heathland (MMH)	Urban

			Freshwater Urban	
Selected Case Studies (ID)	AN5 CR3 CR4	CR3 CR4 CR6	AR1 AR9 FR1 FR2	AL5, AL7 AR8VN7
Featured Tools	ORVal		LEED	Biodiversity Metric Environmental Benefits for Nature ORVal

Table 11: relevant ENCA resources for various topical and policy themes

Theme	Net zero emissions	Climate resilience	Transport	Education
How natural capital can contribute	Woodland creation Peatland restoration Saltmarsh creation Soil management	Natural flood management Sustainable urban drainage Temperature regulation Habitat restoration	Settings for cycling and walking Improve access to green space Supporting network resilience for example, flood risk Mitigating pollution, noise Ecological corridors	Settings for outdoor learning Support for ecological qualifications Check also Cultural Heritage
Relevant Tabs in Services Databook	Carbon reduction Soil	Flood regulation Temperature regulation Biodiversity	Air pollutant removal Noise mitigation	Education Volunteering

Relevant Tabs in Assets Databook	Woodland MMH Coastal margins Farmland	Freshwater Coastal Urban	Various	Various
Selected Case Studies (ID)	VN1 FN2 FN1	FR4 CR4 AL2	AL4 AN5	CL4
Featured Tools	NEVO MESER	MESER	ORVal	

Table 12: relevant ENCA resources for various topical and policy themes

Theme	Levelling up	Social cohesion and loneliness	Cultural heritage	Agriculture
How natural capital can contribute	Addressing regional deficits in accessible natural greenspace	Quality settings for recreation and community events Welcoming outdoor environments Nature-based volunteering	Historic landscapes Settings for ancient monuments	Resilience Diversification Environmental land management
Relevant Tabs in Services Databook	Recreation Amenity	Recreation Volunteering	Recreation Amenity Landscape Non-use values	Food Soil Water quality Regulating services Cultural services
Relevant Tabs in Assets Databook	Urban	Various	Various	Farmland
Selected Case Studies (ID)	FR1 VR3 AR9	CL4 CN4		VN6 FR4, FR5 FR6
Featured Tools	Natural Capital Atlas Maps	ORVal	ORVal MESER	NEVO MESER

8. Annex 2: environmental effect categories

This annex describes the various types of environmental effects and benefits that are covered in the ENCA Services Databook.

8.1 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.

Table 13: key provisioning services and abiotic flows

Service provided by natural capital	Description	Final benefits of in 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 and 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. 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 and energy services
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 oxidised 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 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

8.2 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.

Table 14: key regulating services

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.

Carbon sequestration and storage	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. Flood damage itself is covered as a separate category below.	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. Noise regulation by vegetation is highly spatially specific and is dependent upon sufficient height, depth, permeability and of vegetation to absorb noise.	Reduced noise disturbance giving wellbeing and productivity benefits.
Local climate regulation	Urban economic activity can be impacted by hot summer temperatures. Woodland, grassland, gardens and open waters reduce air temperature and so reduce these heat related costs. Consequently, the creation or loss of urban vegetation will affect this service. More frequent summer heatwaves in future would increase the significance of this service.	A more equable climate, reducing labour productivity losses and air conditioning costs.
Water purification	Ecosystem contribution to water quality through the breakdown or removal of nutrients and other pollutants entering into water bodies. Water which is polluted by heavy metals, excess nutrients or pesticides is filtered as it moves through wetlands, rivers and streams, floodplains and riparian zones, and estuaries and coastal marshes.	Reduced water treatment costs and / or better health outcomes.

Waste remediation	Ecosystems can provide a sink capacity for various forms of organic or inorganic waste and lessen their harmful impact. For example, bioremediation of industrial wastes by disposal on agricultural land.	Avoided treatment costs

8.3 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. Check the Culture and Heritage Capital framework and evidence base being developed by the Department for Culture, Media & Sport.

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).

Table 15: key cultural services

Service provided by natural capital	Description	Final benefits of an improvement in the good
Environmental settings for recreation 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 and 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
Supporting mental health	Personal interaction with and exposure to green space.	health sector cost savings reduced morbidity increased economic output
Enabling educational interactions	Engaging with nature can lead to increased environmental knowledge and general learning experiences, supporting learning and attainment.	The various educational benefits associated with outdoor learning and additional

	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.	earning power arising from ecological knowledge
Volunteering	An important aspect of volunteering is the benefits to society of volunteering opportunities (for example, exercise, social contacts, training, preparing people for employment). These benefits are particularly relevant because of 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.

8.4 Bundled benefits of the natural environment

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.

Table 16: bundled and cross-cutting environmental effects

Category	Description	Final benefits of an improvement in good
Biodiversity	Nature's diversity, commonly referred to as 'biodiversity', is the variety of life on Earth. It includes all species (animals, plants, fungi) and the natural systems and habitats that support them.	Biodiversity underpins to varying degrees all ecosystem services. Species (micro-organisms, fungi, plants) 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, tranquillity 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.
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'. Here the focus is more on wider landscapes that give rise to a range of cultural and aesthetic benefits. It can also 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 and environmental settings can all provide non-use as well as use values.	All benefits relate to individuals, 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 onto 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

8.5 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 different from the more general concept of ‘environmental pressures’ within the natural capital framework (climate change, resource use, chemicals and biosecurity), which directly affects the extent and condition of natural assets. The effects here directly impact on people's welfare.

Table 17: key negative environmental externalities

Environmental effects	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 - 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 visual intrusion Review also 'local environmental amenity' above.	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

9. Annex 3: 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 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.

9.1 Revealed preference and 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). It can also be used as a proxy for the value of a specific service (for example, arable farmland rentals to value a crop provisioning service).

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. 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 example, the cost of water filtration may be used as a proxy for the value of water pollution damages. Another example could be the 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.

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 such as visitors to the site may hold non-use values, but these cannot be assessed using this valuation method.

Random utility models (for example, check 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.

9.2 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 2 advantages:

- they can be applied in a wide range of contexts
- 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

This a survey-style approach that constructs a hypothetical market using a questionnaire.

Respondents answer questions regarding what they are willing to pay for a particular environmental change.

Choice modelling

This 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.

9.3 Subjective wellbeing approaches

These approaches use carefully designed studies to elicit a robust estimate of the subjective wellbeing impact of a change. Such estimates can be converted to a monetary valuation, review Wellbeing guidance for appraisal in the supplementary Green Book guidance (2021). This includes an overview of the main findings from the current wellbeing literature

9.4 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 and noise mitigation. It 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 or 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 3 conditions must hold, the:

- estimate of the costs reflects the qualities of the ecosystem service being lost
- replacement is the least-cost alternative
- replacement would actually be fully demanded in the absence of the asset

Opportunity cost method

Considers the value forgone to protect, enhance or create a particular environmental asset. For example, the opportunity cost of agricultural production is 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.

Target-based method

Where a societally agreed target has been set for reduction of an externality, the shadow price would be the marginal abatement cost of the last unit required to meet the target. This is the basis for the valuation of non-traded carbon prices in the UK. In theory the same approach could also be applied to valuation of changes in biodiversity based on the intersection of national biodiversity targets and an ascending cost curve associated with nature restoration across various habitats. However, unlike carbon, biodiversity is not homogenous. This is an area for further research.

10. Annex 4: glossary

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 to 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. 8 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 (through 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 to 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

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 or cost

Ecological or 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 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 exist, 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 freshwater

Public good - a good or service that is non-rival and non-excludable such as 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 and benefits to individuals as well as additional costs and 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 (such as 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