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Natural capital assessment in landscape-scale land use planning: how it works and key challenges

Key points

- The term 'natural capital' refers to natural assets such as soils and freshwater, that underpin the provision of services to society such as food and drinking water. Using a natural capital approach usually refers to the process of quantifying and potentially valuing these assets to help build nature into decision making. This is increasingly being done spatially, for example to help develop strategic land use plans at city, local authority, or regional scale.
- A wide range of tools is now available to help quantify natural capital assets and the services they help provide. Tools vary in their approach to quantification, whether assets are monetised, and in their suitability to different scales and situations. All tools make significant simplifications of natural processes. They therefore need to be carefully selected to suit the required purpose, and their uncertainties, assumptions and the implications clearly communicated.
- Key challenges in natural capital assessments include difficulties in:
    - appraising the quality rather than just quantity of assets;
    - adequately representing complex natural processes in simplified models;
    - incorporating dynamic and future changes such as the effects of climate change on assets;
    - quantifying and representing uncertainty;
    - incorporating services that are hard to quantify, such as 'cultural' values linked to nature (e.g. how landscapes provide a sense of place) and local or other 'unofficial' forms of knowledge, and;
    - ensuring transparency.
- Given the large number of tools available, it is becoming increasingly important to develop clear frameworks for their use to help ensure quality and comparability in different contexts, and to avoid duplication and lack of coordination across sectors.

Policy makers, land managers and investors are increasingly interested in considering nature – and the services it provides – in decision making. It is expected that quantifying and valuing natural assets will help drive decisions that are more environmentally, economically, and socially sustainable, and help address the climate and biodiversity emergencies. Government and private sector actors are increasingly looking to better recognise this 'natural capital' in public and corporate policies. This is driving a thriving industry of assessment frameworks, methodologies, and tools to quantify natural capital 'assets' ranging from stored carbon to biodiversity. But the sheer number of approaches and the language of natural capital can be confusing. This makes it hard to know which tools may for improve decision-making. This brief introduces natural capital terminology, provides a summary of the 'natural capital approach', outlines its relevance to strategic, landscape scale land use planning, and introduces some of the tools being developed to support the approach.

1 What is 'natural capital'?

Natural capital refers to those natural resources such as soils, rocks, water and biodiversity, that have value to society. Known as natural assets, they provide goods and services such as food, fibre, water purification, and pollination (Fig. 1). The terminology has developed over time and has generated much confusion.

It is the source of key tensions between different communities interested in environmental protection, including:

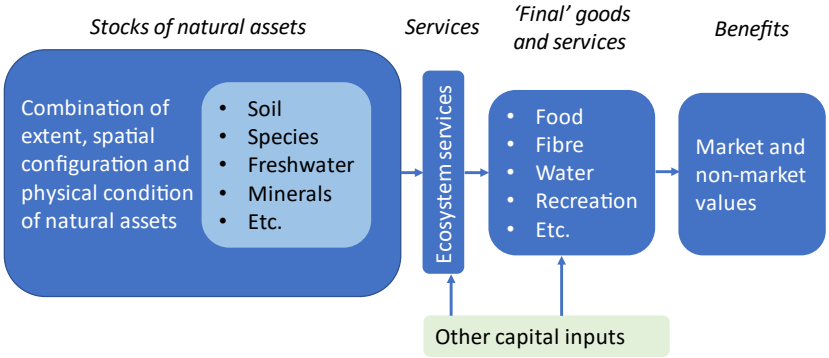


Figure 1: Summary of the link between natural capital assets, ecosystem services and benefits to society. Source Eftec, 2015

1. **Defining boundaries:** Determining which assets and services have value to society, with some actors interested only in understanding a narrow set of services (e.g. carbon storage) whilst others argue that this undervalues the services nature provides.
2. **Applying economics to nature:** The use of the word 'capital', is redolent of giving a monetary value to nature. This often occurs in natural capital approaches but some groups argue that this monetisation is not possible or appropriate.
3. **Technocratic approach:** The approach assumes that complex natural processes and human drivers of environmental change can be broken down and quantified. Some argue that this downplays local or other forms of knowledge and takes the focus away from less quantifiable issues such as politics, which are often where the greatest management challenges lie.

In addition to these different interpretations of natural capital, the term is often used in different ways (Box 1). For example, 'applying a natural capital approach' may be used to refer – in turn – to the methods for quantifying natural assets, providing monetary valuation of services, or simply the steps used in a management cycle that involves some consideration of nature.

2 Natural Capital in UK policy

The term 'natural capital' was coined in the 1970s, but has been more commonly used in UK policy for the past twenty years since the Millennium Ecosystem Assessment in 2005 – a global effort which assessed the consequences of ecosystem change on human wellbeing.

The UK's first National Ecosystem Assessment was conducted in 2009-2011 and the Natural Capital Committee was established in the same year to advise the UK government on natural capital. It played a key role in the development of Defra's 25-year Environment Plan, which intends to "use a natural capital approach as a tool to help us make key choices and long-term decisions" (Defra, 2018). In parallel, natural capital concepts have also become a key part of devolved policy. For example, in Scotland natural capital concepts are included within the new National Planning Framework (NPF4), the National Strategy for Economic Transformation, and the Land Use Strategy. In Northern Ireland they are included within the draft Environment Strategy; and whilst it is not an official part of policy in Wales, it is implicit in the focus on ecosstem services and multiple benefits within the Rural Policy.

Box 1: Definitions (adapted from Natural Capital Committee, 2019; Transparent, 2021)

Natural capital: The part of nature that directly or indirectly underpins value to people, such as soils, freshwater. Combined with other capitals (manufactured, human, financial and social), natural capital supports our ability to provide goods and services into the future and support human wellbeing.

Natural capital accounts: Aggregated monetary or non-monetary valuations of the benefits and costs of maintaining natural capital. National accounts are structured in the same way as accounts for other forms of capital.

Natural capital approach: Management cycle that incorporates natural capital assessment into decision making, usually involving establishing a baseline, assessing scenarios, natural capital valuation, and the development of a management plan.

Natural capital assessment: The process of measuring and valuing natural capital impacts and/or dependencies, using appropriate methods to address a specific question or inform a decision.

Natural capital asset: A component of natural capital, such as soils, species, or freshwaters.

Natural capital baseline: The starting measurement point for natural capital assets, from which relative changes can be assessed.

Natural capital investment: Financial investments in the preservation or enhancement of natural capital assets (e.g. peatland restoration), leaving positive externalities (in the form of ecosystem services such as cleaner water), whilst generating a financial return.

Natural capital offset: Improvement in ecosystem services (usually reduced carbon emissions or biodiversity loss) in one area, in order to compensate for degradation in services elsewhere. This often occurs through markets to trade offset credits representing a unit of improvement, which enable investors to count the improvements towards their targets.

Ecosystem services: The flow of services provided by natural capital assets, such as pollination, water purification, carbon sequestration and flood mitigation. An example of the link between natural capital assets and ecosystem services is the quantity of freshwater in a catchment (asset), which provides drinking water (service).

	International, UK and Scotland accounts	Scotland NC Asset Index	Regional, local and project based natural capital planning
Description	Standardised monetised national NC accounts based on common definitions guided by United Nations System of Environmental Economic Accounting (UN SEEA)	Non-monetary composite index tracking the changes in the capacity of Scotland's terrestrial ecosystems to provide benefits for people.	Range of approaches from monetary accounting, spatial mapping of ecological indicators etc.
Aims	Enable NC incorporation into national accounts and budgets	Monitor Scotland's performance in delivering for nature	Enable NC incorporation in organisational/local planning, monitor impacts on NC
Method	Quantification of asset using national datasets on economic production and/or spatial data, with conversion to monetary values	European Nature Information System Habitat data for Scotland + Common International Classification of Ecosystem Services + expert/opinion-based weighting and quality assessments to create composite index	Various methods, some using similar approach to national accounts, others commonly using spatial datasets of e.g. habitat extent to quantify NC assets and standard approaches to convert to services and values
Asset coverage	Oil, gas, minerals, agriculture biomass, fish caught, water abstraction, renewable energy, carbon sequestration, air pollutants removal, noise mitigation, urban cooling and aesthetic and recreation values captured in house prices	Woodland, inland surface waters, Coastal, Grasslands, Mires, Heathland, Agriculture and cultivated land	Highly variable, from single assets and services (e.g. forest cover for carbon sequestration) to many different asset types.
Valuation	Range of approaches, e.g. resource rents	Monetary values not assigned	Range of approaches where valuation is included
Spatially explicit	No	No	Yes, in some cases
Challenges	No inclusion of biodiversity	Useful for monitoring, but not integrated into mainstream budget processes	Many approaches, not standardised

Table 1: Comparison of three scales of processes applying the natural capital concept within decision making frameworks.

2.1 National scale natural capital assessment

Many separate initiatives incorporating natural capital have developed at different scales and in different sectors (Table 1). The focus in international and national level policy has particularly been on the development of natural capital accounting systems[1] that place a monetary value on natural capital assets and are compatible with broader national accounts. The UK Office of National Statistics (ONS) compiles these accounts for the whole of the UK, including a subset of accounts for Scotland using the same methodology. These do not currently include biodiversity.

Scotland also produces a non-monetary Natural Capital Asset Index (NCAI). This tracks changes in the capacity of Scotland's terrestrial ecosystems to provide benefits for people. This is a National Performance Indicator compiled using national data on the quantity of different habitats and indicators of their quality (defined as habitats' ability to deliver ecosystem services now and into the future, which may be monitored for example through indicators such as the area of certified forest). It draws on expert opinion on the indicators included and weighting of the importance of different services. While all of these approaches use spatial data, they do not provide spatial outputs (e.g. showing accounts for specific landscapes) so are not used directly in spatial planning.

2.2 Sub-national natural capital assessment

Natural capital assessments can also be conducted at regional, local or project level (Fig. 2) to quantify natural

[1] A tool to measure the changes in the stock and condition of natural capital (ecosystems) at a variety of scales and to integrate the flow and value of ecosystem services into accounting and reporting systems in a standard way. (https://environment.ec.europa.eu/topics/nature-and-biodiversity/natural-capital-accounting_en)

assets and potentially create monetised accounts. These assessments can be guided by an array of different frameworks, methodologies, plans and reporting formats, currently with limited standardisation.

They offer useful ideas for using natural capital concepts to support strategic land use planning at sub-national levels. They play an increasingly important role in city development planning (e.g. Greater Manchester Combined Authority), local authority planning, and regional economic planning (e.g. the OxCam Arc).

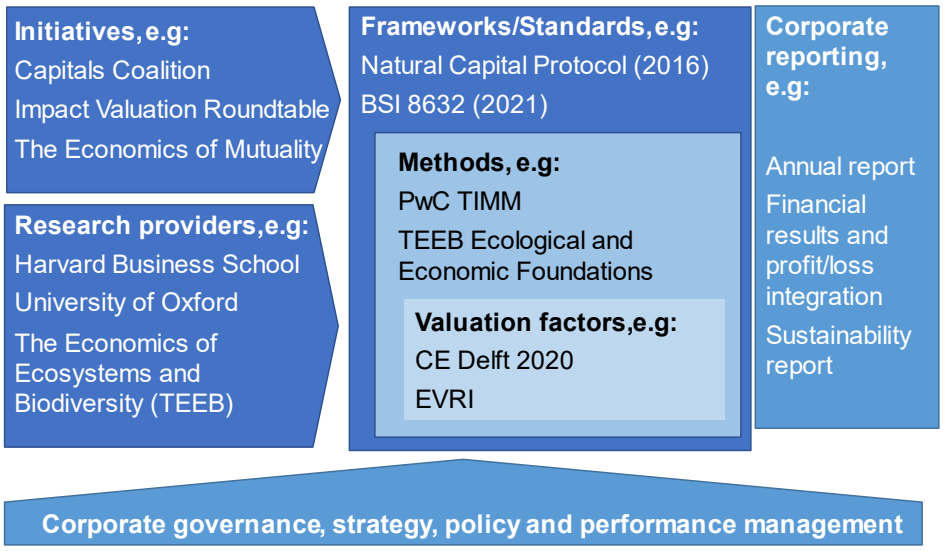


Figure 2: The landscape of actors and instruments supporting the implementation of a natural capital approach at corporate, local and project scales. Adapted from Transparent, 2021.

3 Natural capital mapping and modelling tools

A 'natural capital approach' is often used to refer to the complete cycle of steps in developing a management plan that considers natural capital.

Whilst the details of the approach vary depending on who, why and where it is being applied, there are generally six main steps in the cycle (Fig. 3).

A core part of the natural capital approach involves quantifying natural capital assets and associated ecosystem services, exploring future pressures and scenarios, and producing accounts/valuation to support decision making (steps 2-4 in Fig. 3).

Many mapping and modelling tools have been developed to support this task. There is currently no standardised approach and different methods have been developed for specific tasks. (e.g. deciding how to link assets to services)

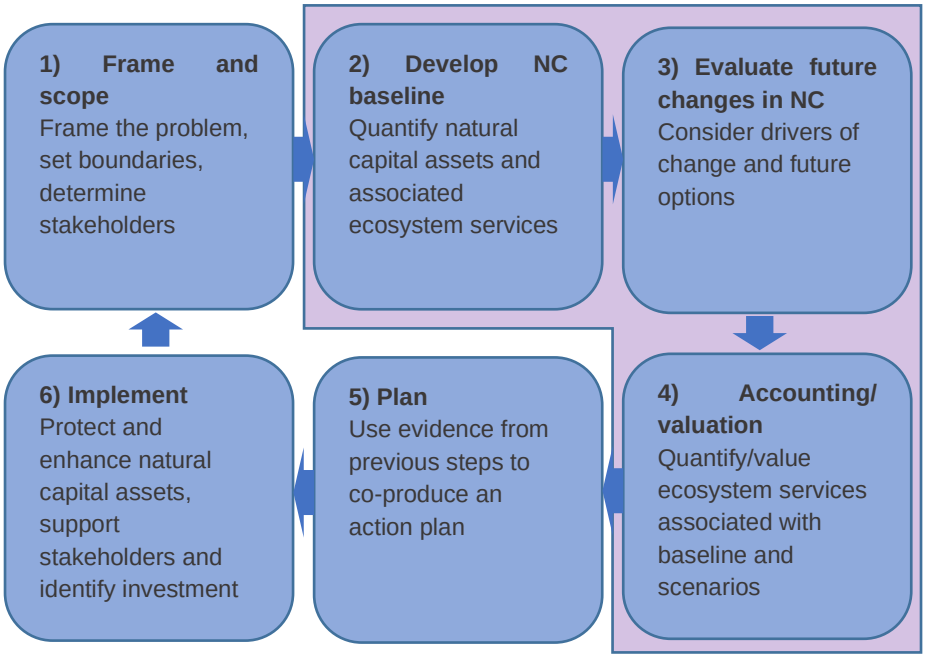


Figure 3: The main steps involved in applying a natural capital approach in decision making. Purple highlight – steps that are the focus of this brief. Source: based on the steps in the Natural Capital Protocol.

This brief cannot review all available tools[2] but examines broadly how they work and some of the key challenges.

The process of assessing natural capital generally involves three main steps, each of which may be supported by technical tools (some tools incorporate all the steps):

1. Establishing a natural capital and ecosystem service baseline
2. Evaluating future changes in natural capital
3. Accounting and valuation

3.1 Establishing a natural capital and ecosystem service baseline

Establishing a baseline involves determining the quantity, quality and location of natural capital assets (e.g. wetland habitats) in an area. Many existing spatial datasets can help with this task, although they often vary in terms of coverage, detail, how up to date they are, and whether they include indicators of the quality of the assets. These assets then need to be linked to the ecosystem services they provide – this is a key task, but one that is conceptually challenging. Different tools use different approaches (see Fig. 4). For example, some use expert opinion and evidence from scientific research to link

[2] several reviews compare different tools – e.g. see Finan et al. 2021; Jacobs, 2020; Nayak et al. 2019

particular habitats/assets to the provision of particular services. The Environmental Benefits from Nature tool uses this approach, applying a matrix of scores linking different habitats and different ecosystem services, which has been developed based on an extensive review of the scientific literature (see Fig. 4 and Box 2). Other tools use spatially explicit models to make the link between assets and services (Box 3). Such models may, for example, use a representation of the physical processes governing water flows (e.g. evaporation, infiltration etc.) to simulate how tree cover reduces water runoff and hence the impact on water pollution or flooding.

Different approaches have developed because there are many ways in which natural assets can be linked to ecosystem services, and different tools may respond to different circumstances. For example, the matrix-based approach is likely to be simpler to implement and cover a wider range of ecosystem services, whilst process-based modelling approaches will be more complicated to implement, generally cover fewer environmental services, but might provide a more nuanced representation of natural processes occurring in different landscapes.

3.2 *Evaluating future changes in natural capital*

Following the development of a natural capital baseline, assessment processes usually aim to quantify future changes in natural capital assets and ecosystem services (Step 3 in Fig. 3). These changes may be due to proposed policy interventions or external factors (e.g. demographic changes in the area). This is often done by establishing 'impact pathways', that define the links between policy interventions and impacts on natural assets. For example, policies to promote afforestation in an area will have impacts on above and below ground carbon stocks, water resources, biodiversity and landscape aesthetics. Many of these impact pathways are well understood, although there may be site specific differences, challenges in quantifying impacts at large scales, and challenges in disaggregating the effects of multiple interventions. External changes and trends affecting the state of natural capital also need to be evaluated so these can be accounted for when evaluating different policy options.

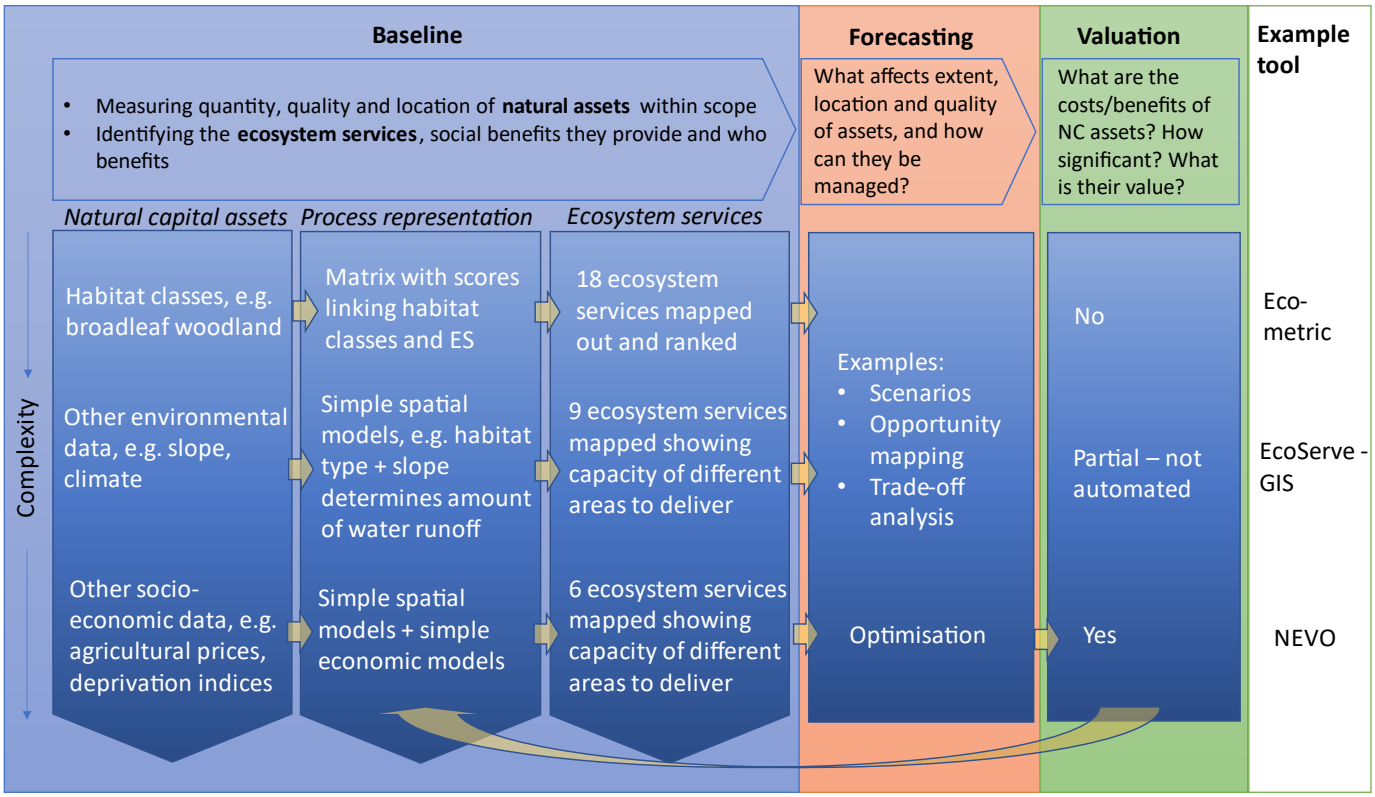


Figure 4: Summary of natural capital assessment using tools. Many tools focus on assessing baseline natural capital assets and use a range of approaches to link these assets to ecosystem services. The approaches vary in complexity, with the most complex tools using spatial models to simulate how ecosystem services flow from underlying environmental assets. They also include broader economic data, allow for optimisation of land use in a particular area, incorporate valuation of services, and include economic feedback (e.g. effects of changes in agricultural prices on land use decisions).

Box 2: OxCam Arc Local Natural Capital Plan

Summary: Aims to help stakeholders with strategic land use decision making across the five ceremonial counties between Oxford and Cambridge, which are a focus for future economic development. It will help to ensure the protection of high-quality environmental assets beyond designated sites. It also aims to help identify opportunities for enhancing the natural environment, value natural capital, and help coordinate decision making across sectors.

Natural capital assessment approach: The assessment used four main steps to assess natural capital across the region.

1. Ordnance Survey maps were first used in conjunction with other spatial datasets to create a classified habitat map of the region. An existing tool (EcoServe-GIS, now being redeveloped as EcoServR) was used to classify the different habitats into a manageable number consistent with other data. This was complemented by a parallel project to create a methodology to assess habitat condition based on existing datasets and inference.
2. Another tool, called Eco-metric (now Natural England's EBN tool) was then used to link the natural capital assets with ecosystem services. Eco-metric uses a scoring matrix approach (see extract below) in which different habitat types are associated with 18 different ecosystem services, with scores assigned to these based on habitat condition, spatial location, delivery risk and the time taken for new habitats to reach maturity. The matrix was developed using an extensive review of the scientific literature.
3. Opportunities and risks: These were identified through work with stakeholders and reference to existing work, and used to develop opportunity and risk maps.
4. A Natural Capital Account was developed for the region with quantitative data on natural capital assets (e.g. woodland area) and the value of ecosystem services (e.g. flood regulation provided by woodlands).

Habitat	Food production	Wood production	Fish production	Water supply	Flood regulation	Erosion protection	Water quality regulation	Carbon storage	Air quality regulation	Cooling and shading	Noise reduction	Pollination	Pest control	Recreation	Aesthetic value	Education	Interaction with nature	Sense of place	Biodiversity
Broadleaved, mixed and yew semi-natural woodland	1	6	0	3	9	10	10	10	6	10	8	7	8	10	10	10	10	10	8
Broadleaved, mixed and yew plantation	0	8	0	2	9	8	8	9	6	10	8	6	6	10	10	6	7	8	5
Native pine woodlands	0	0	0	3	9	8	6	7	8	10	10	6	8	10	10	10	10	10	8
Coniferous plantation	0	10	0	1	10	6	5	8	10	10	10	2	6	10	6	6	4	6	2
Wood pasture and parkland with scattered trees	5	2	0	7	6	8	6	5	3	6	6	7	8	10	10	8	8	10	10
Traditional orchards	5	1	0	7	8	8	5	5	4	8	6	7	8	8	10	8	7	10	8
Dense scrub	1	2	0	4	6	8	5	6	7	6	6	7	10	8	8	6	8	6	5
Hedgerows	1	1	0	4	6	8	5	5	8	6	6	8	10	8	10	8	10	10	10
Felled woodland	0	0	0	4	1	0	1	2	0	1	0	1	3	5	1	1	1	1	2
Tall herb and fern	1	0	0	8	5	8	5	4	1	2	1	7	10	8	10	6	8	4	3

Extract from matrix of ecosystem service scores for different habitats that underlies the EBN tool approach similar to that used in the OxCam Arc project. Source: Smith (2021)

Different land use scenarios may be considered at this stage, to explore their impacts on natural capital. These can include 'intervention' scenarios that analyse impacts of specific interventions; 'exploratory' scenarios, that often explore impacts of unexpected futures; and 'counterfactual' scenarios that look at the alternative state of a site, for example if no changes were made (Natural Capital Coalition, 2016). Spatial mapping tools can make this process much easier and may have elements of impact pathways built in to help explore different scenarios. For example, if demographic data for an area are included, information on projected demographic changes in local communities can be used to evaluate how this is likely to alter pressures on local natural capital assets.

3.3 Accounting and valuation

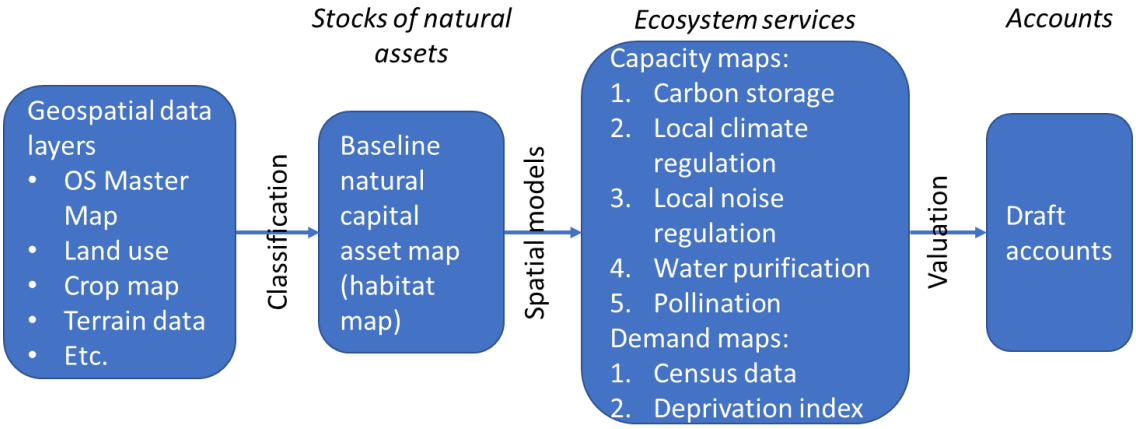
Monetary valuation is not always part of natural capital assessments, but it can help to demonstrate or justify attention to natural capital. Monetisation can help include environmental considerations in processes such as budgeting, evaluating potential profits and losses, and improving indicators of environmental performance. Several methods can be used to assign values for ecosystem services. These include qualitative approaches (e.g. opinion surveys), quantitative non-

Box 3: South Downs National Park natural capital investment areas

Summary: Twelve areas across the region (primarily on the edge or beyond the National Park's boundaries) were identified as 'Natural Capital Investment Areas'; key areas for long-term investment in more green infrastructure. The identification of these areas and priority investments used a natural capital approach, in combination with partnership working between the Park and many stakeholders, to develop a People and Nature Network Masterplan.

Natural capital assessment approach: The assessment used a four-stage process for assessing natural capital based on an approach developed under EcoServe-GIS (now called EcoServR):

1. Development of a natural capital asset baseline, in the form of a habitat map, created from the combination of different existing spatial datasets for the region. Socio-economic factors (e.g. health deprivation) were also included in this classification process to enable some spatial analysis of the interactions between these factors.
2. Spatial models were then used to link natural capital assets to the provision of five ecosystem services (carbon storage, local climate regulation, local noise regulation, water purification, and pollination), based on simplified representation of the underlying processes. For example, in EcoServe-GIS, water purification is assumed to be linked to the roughness and steepness of slopes, which are factors controlled by the habitat type and topography. Areas that are less steep and have more varied vegetation are then scored higher in terms of their capacity to limit runoff and pollution. Applying these models creates scored 'capacity maps' showing the capacity of different parts of the landscape to deliver ecosystem services.
3. Census data and multiple deprivation index data were combined through spatial models to create maps of ecosystem service demand. The capacity and demand maps can be overlaid to explore areas where ecosystem services are under pressure and identify management options.
4. Development of draft natural capital accounts for the Park.



monetary approaches (e.g. tonnes of carbon), and monetary valuation (e.g. current market prices for replacing the natural capital asset with an artificial substitute). Some natural capital mapping tools integrate valuation into their platforms (e.g. inVEST and NEVO). Databases exist to help value environmental assets, such as the Environmental Valuation Reference Inventory (EVRI).

While the complexity of the different tools is extremely variable, greater complexity may not necessarily improve the natural capital assessment and the tool needs to be carefully selected based on user needs.

4 Stakeholder engagement

Involvement of stakeholders is crucial in natural capital assessment. Whilst the mapping and modelling of natural capital can be conducted by experts, stakeholder engagement helps ensure that local data are incorporated and future change is better understood.

Stakeholders are normally involved at specific points in the natural capital planning process, often through in-person or online workshops (Fish et al. 2011). The main methods used in consultation processes include:

- **Survey-based:** Use of questionnaires, interviews or focus groups to gain insights into peoples' attitudes, values, knowledge and behaviour.
- **Deliberative:** Mainly discussion group-based methods that are relatively open and exploratory in nature to develop reasoned assessment of an issue through debate and learning. Citizen juries and deliberative opinion polls can also be used to explore the decision-making process and also reach decisions.

- **Deliberative-analytical:** Involving stakeholders in informing technical tools for decision making, for example the design and content of analytical models that simulate local ecosystem service supply. Deliberative-analytical approaches are commonly applied in natural capital assessment and in many of the tools discussed above.

In such tools, deliberation with stakeholders is often used, for example, to determine what ecosystem services to cover or solicit local information on natural capital asset quality, although few tools formally incorporate this information into their approach.

Various methods can be used to structure stakeholder deliberation when these tools are applied, such as:

- Scenarios, potentially visualised through artistic representation; narrative storylines; computer simulation etc.
- Ranking and scoring
- Multi-criteria analysis to weigh up different criteria against each other
- Participatory mapping to help draw out spatial relationships in a landscape and relations between different stakeholder interests
- Games to engage stakeholders in the issue and simulate real-world trade-offs

5 Opportunities and challenges

The concept of natural capital provides an opportunity to integrate nature into decision making in a way that potentially increases its influence relative to other forms of capital asset.

The assessment of natural capital is becoming easier with the availability of increasingly detailed spatial datasets, as well as more advanced and more widely accessible tools to process data. However, the approach is still in its relative infancy, and there are several key challenges.

5.1 Incorporating natural capital quality indicators

Many existing environmental datasets include information on the quantity of natural capital assets, but there are fewer datasets on the asset quality. For example, different habitats in the UK have been extensively mapped and classified, but there is limited data on their current condition. Often this information is held in local datasets, so may not have the spatial coverage required, and it can be difficult to incorporate the information into assessment tools using standardised data.

Another challenge is capturing the effects of land management changes. For example, tools that use habitat types as the basis for assessment may only be able to simulate the change in ecosystem services due to change in the habitat type rather than a change in management of the habitat (e.g. farming improved grassland using a new soil conservation strategy but not altering the land use classification).

While there has been some progress, for example in making links using routinely collected data on habitat status where it exists (Watson et al. 2022), these issues raise risks of tools providing inaccurate results (Hooper et al. 2019).

5.2 Over-simplifying complex natural processes

All natural capital assessment tools make large simplifications about natural processes, rely on numerous assumptions and often limited or poor quality data to represent complex assets.

A key issue in many existing tools is their basis in habitat maps, where different habitats are used as proxies for delivering a wide range of ecosystem services. This may be valid for some services, such as carbon sequestration. However, as noted above, this could be particularly problematic for services such as flood mitigation, in which a multitude of physical factors can be primary controls with limited ability to infer flood risk from different habitats. In addition, tools often assume that the processes governing the services that different habitats provide are the same in different areas and at different scales, which is not necessarily the case (Paulin et al. 2020).

5.3 Accounting for dynamic changes

Similarly, natural capital assessment is not well designed to account for dynamic changes within and beyond the system being assessed. For example, changes in the wider economy that affect the value of land and hence decisions made around land management.

Some models try to integrate these effects, but others are focussed more narrowly on environmental variables. This is not necessarily a problem, but could, for example, become a challenge if a region is concurrently developing economic strategies (based on economic models) and regional land use frameworks focussed on natural capital. Another example surrounds how the effects of climate change are accounted for – natural capital approaches may incorporate climate change projections within scenario planning and forecasting processes, but few existing mapping and modelling tools formally account for how natural capital assets and associated ecosystem services will vary with climate change. The differentiated impacts of climate change will directly and indirectly interact to produce cumulative impacts on the assets that comprise natural capital, potentially producing significant effects on species, ecosystem function and the ecosystem services they provide. Of particular concern is that the potential for ecosystems to mitigate climate (climate regulation) is reduced, or worse, change means

assets (such as peatlands) increase greenhouse gas emissions.

5.4 Quantifying uncertainty

Given the limitations of environmental datasets, and the simplifications and assumptions that must be made in applying tools for natural capital assessment, it is important to quantify the uncertainties involved in the outputs. Uncertainties in natural capital assessment may vary in three main dimensions (Bryant and Hamel, 2016):

1. Location: for example, whether it stems from how natural capital assets are defined, the quality of input data, or how the outputs are interpreted.
2. Nature: whether uncertainty originates from imperfect knowledge of, or natural variability in, natural systems.
3. Magnitude: whether the uncertainty is critical to decision making and how it compares with other uncertainties.

Uncertainty estimation is particularly difficult in natural capital assessments, given their breadth, and uncertainty is rarely quantified (Hamel and Bryant, 2017), which could have significant implications for decision making.

5.5 Incorporating services that are hard to quantify

Some ecosystem services are particularly difficult to quantify and value. For example, valuing natural assets that provide cultural ecosystem services (e.g. how the landscape provides people with benefits such as cultural identity, a sense of home, and spiritual experience) is notoriously difficult or judged as inappropriate. Key issues include (Jones et al., 2021):

- A lack of understanding of the cultural benefits that people receive from nature.
- Difficulties in defining cultural ecosystem services beyond basic indicators such as recreation space provision.
- A lack of data, often as relationships with nature that are site-specific cannot be generalised or modelled.
- Few modelling methodologies exist.

Whilst these limitations are often acknowledged and there are ongoing efforts to improve assessment, many assessments simply ignore these contributions, or use over-simplistic indicators. As discussed in section 3.3, a related issue is the challenge of how to assign economic values to ecosystem services that do not have a market value.

5.6 Ensuring transparency

As shown in Fig. 2 there is now a wide array of initiatives for assessing natural capital, particularly in the private sector and in sub-national planning. Whilst there are growing efforts to standardise approaches (e.g. British Standard, BSI 8632), many assessments are carried out in house or by consultancies using approaches and datasets that are not public. This makes it difficult to evaluate the underlying assumptions and hence the robustness of outputs. In addition, many tools require specialist knowledge and significant resources, as they use large volumes of spatial data and complex modelling approaches. Explicit communication of assumptions and uncertainties to non-experts is therefore particularly important.

5.7 Monitoring impact

There is a growing natural capital assessment industry and the production of tools to support these assessments. This is a good indicator of demand to incorporate natural capital into decision making in the public and private sectors. However, there is still relatively little evidence demonstrating the impact that these approaches are having on decision making.

A better understanding of impact would be useful for feeding back into the design of better tools and addressing scepticism among some stakeholders that the approaches are just an academic exercise distant from those making decisions about land management.

5.8 Promoting a technocratic world view

The focus of the natural capital approach on quantifying natural assets and services promotes a particular world view that assumes the complexities of natural processes and the benefits they provide to humans can be quantified and that decisions are primarily based on quantitative data.

This is only one perspective, with much research and experience suggesting that there are other ways of understanding human interaction with natural processes that emphasise different forms of knowledge (e.g. indigenous knowledge). The result is an approach that is often technocratic, using official datasets that are partial and narrowly focussed. This may cause challenges in involving certain groups within natural capital assessment processes and their buy-in to eventual decision making.

6 Conclusions

Natural capital assessment is increasingly being trialled to support strategic, landscape scale land use planning. While there has been little formal research on the impact this is having on decision making, it has certainly increased attention towards the range of benefits provided by nature in public and private sector decision making.

The natural capital approach also provides a more systematic framework for incorporating nature into these processes. Mapping and modelling tools can be useful for supporting many of the steps involved in applying a natural capital approach, given the difficulties in defining

and quantifying natural capital assets, and representing the complex natural processes that link these assets to ecosystem services.

However, the number of tools that are available, the diversity of approaches they use, and a lack of transparency and accessibility for some tools, risks causing confusion among those interested in applying these tools and calls for more clarity in what different tools offer. More fundamentally, all tools make significant assumptions and have limitations that are not always clear to users. These need to be clearly understood to ensure that the implementation of natural capital approaches improves on existing environmental management methods.

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