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SFS Economic Valuation: Logic Chains

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Abbreviations Used in this Annex

AHDB	Agriculture and Horticulture Development Board
BAP	Biodiversity Action Plan
CuRVe	Current relative value
DECC	Department of Energy & Climate Change
DECCA	Diversity, Extent, Condition, Connectivity and Adaptability
Defra	Department for Environment, Food & Rural Affairs
eftec	Economics for the Environment Consultancy
ELS	Entry Level Stewardship
ENCA	Enabling a Natural Capital Approach
ERAMMP	Environment and Rural Affairs Monitoring & Modelling Programme
ES	Environmental Stewardship
GHG	Greenhouse gas
HLS	Higher Level Stewardship
IPCC	Intergovernmental Panel on Climate Change
LA	Local Authority
NPK	Nitrogen, Phosphorous and Potassium
NRW	Natural Resource Wales
NWEBS	National Water Environment Benefits
OFWAT	Water Services Regulation Authority
ORVal	Outdoor Recreation Valuation [modelling tool]
PM2.5	Particulate Matter - less than 2.5 micrometres in diameter
PV	Present Value
RAG	Red-Amber-Green rating
SDA	Severely Disadvantaged Areas
SFS	Sustainable Farming Scheme
SLM	Sustainable Land Management
SP	Stated Preference
SSSI	Sites of Special Scientific Interest
tCO_2e	Tonnes of Carbon Dioxide Equivalent
UKCEH	UK Centre for Ecology & Hydrology
WAAD	Weighted annual average damage
WFD	Water Framework Directive
WTP	Willingness to Pay

Abbreviations and some of the technical terms used in this report are expanded on in the programme glossaries: https://erammp.wales/en/glossary (English) and https://erammp.cymru/geirfa (Welsh)

Contents

SUMMARY

The purpose of this report is to input to the development of potential payment rates for measures by farmers under the Sustainable Farming Scheme (SFS) in Wales by providing environmental-valuation evidence. Logic chains for specific policy outcomes are developed to communicate evidence on how different social benefits from policy outcomes can be achieved and valued. Therefore, the focus is on social values for public goods, although private values are also identified.

Logic chains have been developed for outcomes the SFS will aim to achieve:

1. Air Quality
2. Climate regulation: Increased tree cover; Saltmarsh; Peatland; Grassland
3. Decarbonisation
4. Flood risk mitigation
5. Water quality
6. Resilient ecosystems and species recovery
7. Animal health and wellbeing
8. Soil husbandry
9. Direct value of biodiversity

The evidence used has been cross-referenced to the ERAMMP evidence packs on the SFS (ERAMMP Report-10) and National Forest for Wales (ERAMMP Report-32). However, those evidence packs contain considerably greater discussion of the evidence than is possible to summarise in logic chains, which need to be brief to fulfil their policy communication purpose. The Draft Logic Chains (Section 3) have benefited from review by UKCEH subject experts to check for consistency with the evidence in Reports-10 and 32. However, the final content in the responsibility of the named authors.

Based on the outcomes identified in these logic chains, the values of public goods are considered. As these values are mainly for non-market goods, a range of valuation evidence is considered. Value transfer is used to interpret current valuation evidence and identify relevant unit values for the benefits. Valuations for some public goods are readily available and practical to apply. For others the evidence base is out-of-date, meaning it may not reflect people's preferences within current socio-economic conditions, which adds uncertainties if applied to value SFS outcomes in Wales.

It should be noted that the social values identified are just one input into payment design, with other factors relating to farm businesses (e.g. levels of risk, incentives), social outcomes (e.g. employment) and value for money, etc. Identifying values is NOT the same as recommending payment rates, which must consider the synergies and overlaps between actions when interpreting values. These are discussed in Section 5, and compared to the Integrated Assessments of the ERAMMP Evidence Packs which identified many of these synergies and co-benefits (as well as some trade-offs).

Analysis of these overlaps suggests there are more synergies than trade-offs, and so there is greater risk in under-appreciating synergies in the physical overlaps of actions, and therefore their multiple benefits, than in double-paying for outcomes. The analysis of overlaps has been compared to the ERAMMP evidence packs on the SFS and National Forest for Wales. They are consistent in identifying similar areas with greater policy overlaps, and in giving a moderate confidence rating to the majority of the evidence base relied on.

The methods and material in this report have been independently reviewed by eftec, Welsh Government staff and UKCEH scientists from within the ERAMMP team.

1 INTRODUCTION

1.1 Purpose

The purpose of this report is to input to the development of potential payment rates for measures by farmers under the Sustainable Farming Scheme (SFS) in Wales by providing environment-valuation evidence. Logic chains for specific policy outcomes are developed to make clear to those developing SFS policy how different social benefits from policy outcomes can be achieved and valued. Therefore, the focus is on communicating this basis for the evidence on social values for public goods, although private values are also identified.

The logic chains are developed to show the benefits that specific measures by farmers can deliver and to present the available valuation evidence (i.e. the size and variation in the social value of public goods) that can inform the design of SFS payments. The work also helps show the factors through which potential benefits vary, for example by geographical location. The logic chains summarise this evidence for communication, so do not discuss all the factors likely to cause variation in potential benefits and the influence of other inputs (e.g. skills and motivation, etc. expected to some role). However, confidence levels in the evidence used are noted through a RAG rating. These levels of confidence have been checked against the confidence ratings provided in the Integrated Assessments of the ERAMMP SFS and National Forest Evidence Packs.

The additional benefits are assessed above the regulatory baseline. This is broadly defined by existing cross-compliance and any new regulations on agricultural pollution. Further work would be needed to assess the influence of different baseline assumptions, looking at logic chains for different sectors and landscape of Wales, which is beyond the scope of this analysis.

The specific benefits are described in terms of levels of ecosystem services, the public goods they provide, and the societal value of those public goods. The focus is on the value to current and future generations in Wales. However, some benefits arise to people outside Wales, in particular climate regulation benefits are global, and other benefits, such as water quality and air quality, may be shared with adjacent areas of England. These benefits outside Wales are not assessed separately.

1.2 Approach

The logic chains are designed to capture key issues and are not intended to be comprehensive. They have drawn on, and attempted to mirror the issues and language in, the Welsh Government Consultation 'Sustainable Farming and Our Land' (October 2019)[1]. They cover representative actions which evidence shows should[2] lead to Sustainable Land Management (SLM) outcomes.

As a result the different logic chains are defined according to the policy issues in the Consultation. This means that there are some differences between logic chains that are based on ecosystem services (e.g. carbon sequestration) and those based on management measures (e.g. soil husbandry).

There are overlaps between the actions and outcomes considered in the logic chains, which are reviewed in Section 5. This can be compared with the Integrated Assessments in the ERAMMP Evidence Packs which

[1] https://gov.wales/sites/default/files/consultations/2019-07/brexit-consultation-document.pdf
[2] The level of confidence in the outcomes is shown with results, see Section 2.12.

provided a look-up table of co-benefits and trade-offs for different management practices and/or woodland types, and a colour coded confidence level of the evidence base which underpinned that judgement.

The work incorporates comments from a group of policy and data experts within the Welsh Government and NRW; evidence from elsewhere in the ERAMMP programme and the resilience analysis in the CURVE report[3] discussed further in Box 2.1. The evidence used has also been cross-referenced to the ERAMMP evidence packs on the SFS (ERAMMP Report-10) and National Forest for Wales (ERAMMP Report-32). However, those evidence packs contain considerably greater discussion of the evidence than is possible to summarise in logic chains, which need to be brief to fulfil their policy communication purpose.

[3] Naumann, E.-K., Medcalf, K., 2020. Current relative value (CuRVe) map atlas for ecosystem resilience in Wales. NRW Evidence Report No: 415, 88pp, Natural Resources Wales, Bangor.

2 BACKGROUND

This section provides brief background on the structure of logic chains and the economic valuation evidence linked to them. Interactions between logic chains are noted, but are assessed further in Section 5.

2.1 Logic chains

Logic chains are used as a tool to represent the relationships between ecosystem assets (extent, condition and location), flows of ecosystem services, the provision of goods and services (public and private) and their value to society. This section shows the main components of a simple general logic chain.

The logic chains simplify relationships that are often highly complex, and do not fully reflect:

- Many local environmental factors causing variations in the relationships,
- The timescales for changes along logic chains, which can vary from relatively short (1-2 years), to effects with lags of 5-10 years (e.g. for nutrient content in soils to reduce) to changes over decades (e.g. afforestation), and
- Potential negative impacts (to public or private goods) – these could be incorporated into a more complex logic chain structure.

These and other policy aspects are not included in order to keep logic chains simple but are explicitly included in the ERAMMP Evidence Packs. The relationships in the logic chains are given a Red-Amber-Green (RAG) confidence rating (see below) that reflects such variables. For a thorough review of these factors, see the ERAMMP Evidence Packs on the SFS (Report-10) and National Forest Wales (Report-32).

Payment rates that reflect the value of delivering public goods need to be based on the definition and measurement of those public goods, and the additional value of changes to them. These are shown by the logic chains, which link SFS measures to public goods and values. Management measures are drawn from those discussed in the 2019 consultation[4]. A further measure, business support, is cross-cutting, as it increases capacity and skills to achieve all SFS outcomes, but is not considered specific to, and so not included in, individual logic chains.

2.1.1 General Logic Chain

A general logic chain that links the assets to values is shown in Figure 2.1. It also shows external pressures can affect each component of the logic chain and that measures can affect the characteristics of the asset, ecological functions or ecosystem services.

[4] Available at: https://gov.wales/sites/default/files/consultations/2019-07/brexit-consultation-document.pdf

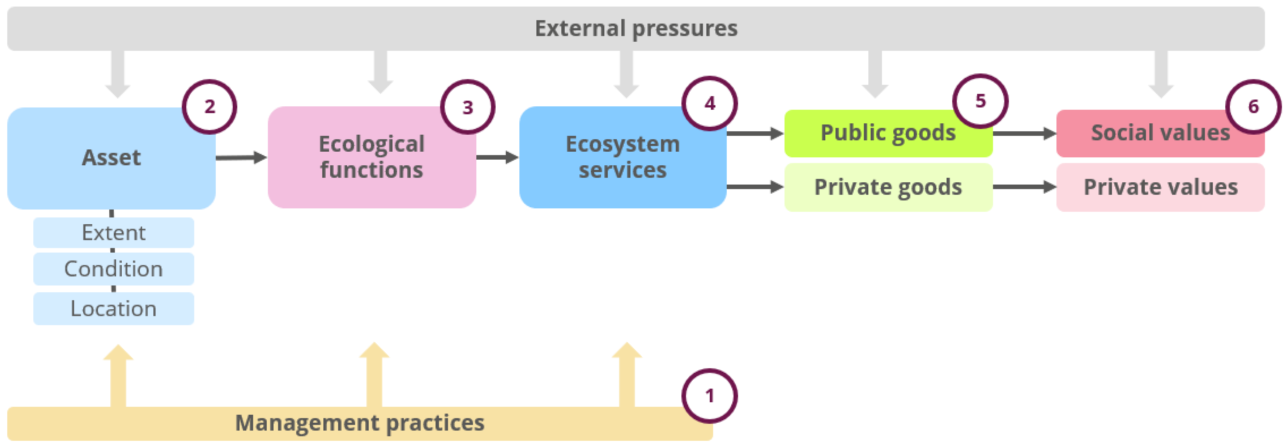

Figure 2.1: General logic chain

A brief description of each component of the logic chain is provided below. The logic chains are a simplification of the processes involved, and do not provide a comprehensive level detail in each component. They do not reflect every element of the 'farming system', which includes environment (e.g. soil) and socio-economic (e.g. property rights, workforce) conditions, and management practices (extent, intensity, type of farming activity). However, the key point about logic chains is that they give sufficient information to allow a combination of evidence along the chain to inform policy:

Step	Explanation
①	**Management practices:** land management measures including: adjustment of land use intensity; creation of habitats, woodlands and landscape features, and; restoration actions intended to deliver long term environmental benefits.
②	**Asset:** the stock of renewable and non-renewable resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people - captures the type, extent, condition and location of the land area being managed.
③	**Ecological functions:** The biological, geochemical and physical processes and components that take place or occur within an ecosystem. In effect, the biological underpinning of ecosystem service provision through processes such as pollination and pest control. See Box 2.1.
④	**Ecosystem services**: the contributions of ecosystems to benefits to economic and other human activity. Typically, classified between provisioning services (products obtained from ecosystems, e.g. food or timber), regulating services (benefits obtained from the regulating of ecosystem processes, e.g. climate sequestration) and cultural services (non-material benefits individuals obtain from ecosystems, e.g. recreation or aesthetic benefits). .
⑤	**Public goods:** A set of goods that provide benefits and for which there is no functioning market[5], e.g. thriving plants and wildlife, climate change mitigation and adaptation. The Welsh Government proposes to reward farmers for delivering Sustainable Land Management outcomes not supported by the market, principally environmental outcomes.
⑥	**Social values:** the values attached by society to those public goods, expressed in economic terms. Benefits to those taking the management actions are recorded as private values (e.g. cost savings from reduced fuel use).
Notes	**External pressures:** factors beyond the landowners' control, e.g. atmospheric deposition of pollutant nitrogen on sensitive sites, climate change, growing population.

Social values aim to reflect the changes in welfare of all in society. In this case 'society' refers mainly to the resident population of Wales. Changes in the environment can affect peoples' welfare in different ways – see Section 2.2.1.

[5] Technically, public goods arise when the goods are non-rival and non-excludable, which inhibits market activity.

It should also be noted that SFS measures can generate private goods (that are traded in markets), and have private values to the farmer/ land manager or other parties[6]. Some benefits have both public and private good aspects – for example soil conservation may benefit farmers (through better productivity) and wider society (through carbon storage).

Confidence levels are given for the evidence behind each step in the Logic chain. It is important to highlight potential variation between theory and practice, and state the level of confidence in the connections made. Therefore, each step in the logic chain is given a confidence rating, which is described in Table 2.1.

Table 2.1: Levels of confidence in logic chain evidence

Level of confidence	Symbol	Description of confidence
Low	🔴	Evidence is partial and significant expert judgement-based assumptions are made so that the data provides only order of magnitude estimates of physical quantity or monetary value
Medium	🟡	Science-based assumptions and published data are used but there is some uncertainty in combining them, resulting in reasonable confidence in using the data to guide decisions and spending choices.
High	🟢	Evidence is peer reviewed or based on published guidance so there is good confidence in using the data to support specific decisions and spending choices.

Public policy evidence is required to be cautious of "optimism bias", particularly where evidence is limited. With SFS interventions, there is at least an equal risk of the benefits assessed through the logic chains being partial, underestimating the full scale of benefits of different interventions due to evidence limitations including harder to measure and/or evaluate environmental benefits (see Section 2.2.2). Where evidence is limited, it can be appropriate to apply the precautionary principle, particularly to ensure full consideration of impacts on future generations, which can face greater uncertainties.

2.1.2 Application of logic chains to Sustainable Farm Scheme

The logic chains are used in Section 3 to link measures to manage assets, functions and/or ecosystem services to social values target outcomes from the SFS. The value of the outcomes is then examined in Section 4. It should be noted that the values identified are just one input to payment design, with other factors relating to farm businesses (e.g. risks, incentives), social outcomes (e.g. employment) and value for money, etc.

Policies may choose to pay for outcomes at different stages in the logic chain. Therefore, the choices of how much to pay and what to associate the payment with (which could be, amongst others, a contract for actions, actions delivered, a change in assets, a change in ecosystem services, or a change in public goods) are distinct but interrelated decisions. Also, payments at different stages in the logic chains can result in different incentives.

As noted above, the logic chains are illustrative to inform policy, and could be developed in more detail and with specialist input based on further published evidence and research. Relevant sources include the extensive literature review of the most recent evidence concerning links between management measures and the sustainable farming outcomes[7].

[6] Private goods benefit companies and individuals, e.g. food, enhancing water quality and reducing treatment costs, improving soil function. Private values are the values associated with private goods.
Note that some goods can have public and private benefit: for example clean and plentiful water in the natural environment is a public good, but is sold to households and businesses as a private good.
[7] See SFS evidence pack: https://erammp.wales/en/r-sfs-evidence-pack

Users of logic chains should be aware of potential for over-simplification of issues, and also that simplifications increase the risk for compound error to develop along a logic chain. The logic chains note the main variations in benefits from actions according to geography or context, but they cannot reflect local or farm level variation in actual benefits from farmer actions. The logic chains are therefore complemented by the illustrative farms analysis being undertaken by ADAS, and the environmentally modelling being undertaken in other parts of the ERAMMP programme of work.

Box 2.1: Diversity, Resilience and Ecological Functions in Logic Chains

The logic chains are necessarily a simplification of the processes that will link management actions in farming to the societal value of public goods outcomes. The "ecological functions" step helps capture environmental processes, and is also used to recognise that the environment should not only be viewed as providing distinct ecosystem services, but also has value as a renewable asset that contributes to overall resilience. The Welsh Government Consultation 'Sustainable Farming and Our Land' (October 2019) gives NRW's definition of ecological resilience as the capacity of ecosystems to deal with disturbances, either by resisting them, recovering from them, or adapting to them, while retaining their ability to deliver services and benefits now and in the future.

Numerous factors, including biodiversity, play a role in maintaining a resilient, functioning ecosystem. This resilience has value which is distinct from the non-use values of biodiversity examined in Section 3.6[a]. Measures are drawn from a spatial analysis of the resilience of Welsh ecosystems[b], which uses data to measure proxies for five broad attributes of resilience: Diversity, Extent, Condition, Connectivity, and Adaptability (DECCA). The data used is a mix of state, pressures and risk metrics, and there are risks of over-simplification (e.g. increasing tree cover may or may not increase semi-natural habitat diversity - this depends on the type of woodland created and whether woodland is swapped for more than one other habitat across an area). This mapping faces data limitations, such as using static data (e.g. extent of habitats) to represent dynamic assets and processes (e.g. habitat change). However, it provides data that supports the objectives of the Environment Act (Wales) 2016 by measuring improvement in the resilience of ecosystems against the DECCA attributes. They help indicate where habitats have the right level of connectivity, diversity, condition, and scale for the species they support, which is more robust than relying only on indicator species data.

The impact of SFS measures on resilience will depend on what changes it can achieve relative to the baseline state of farms within the scheme. An assessment of the Glastir scheme in 2017 found that the baseline was atypical of the overall farmed landscape, as land entering the scheme already had many more attributes thought to underpin resilience (e.g. diversity, connectivity) than land which didn't[c].

[a] https://forestry.gov.scot/publications/736-feasibility-study-for-the-valuation-of-forest-biodiversity
[b] Naumann, E.-K., Medcalf, K., 2020. Current relative value (CuRVe) map atlas for ecosystem resilience in Wales. NRW Evidence Report No: 415, 88pp, Natural Resources Wales, Bangor.
[c] https://erammp.wales/sites/default/files/GMEP-Final-Report-2017.pdf

2.2 Economic Values for Environmental Changes

This section describes types of economic value and their use in SFS and broad approaches to valuation. The Green Book p.63[8] sets out the circumstances for using alternative valuation approaches, such as damage costs, in the context of appraisals. Note also the reference to ENCA below, linked to the Green Book.

2.2.1 Types of economic value

Economic valuation is a way to understand how much something is worth to particular people or to society as a whole, regardless of whether or not it is traded in markets. There are no markets to buy and sell many environment goods and services, including by definition most public goods. The available valuation methods measure a change in the quality or quantity of the benefits (typically classified as ecosystem services) provided by the environment (which is considered an asset), where change could be a deterioration or an improvement. Qualitative understanding of the change, and usually quantification of benefits (or losses), is required before monetary valuation of environmental effects can be undertaken[9].

Environmental economics categorises economic values for changes in goods and services, including public goods as:

- ***Use values*** involve interactions with the environment directly (e.g. for farming), indirectly (e.g. through climate regulation benefits), or through having the option to use the environment in the future.
- ***Non-use values*** involve benefits that arise from the knowledge that the environment is maintained. These values can be motivated in different ways: altruism (knowing that others can enjoy the environment), bequest (knowing that environmental resources will be passed on to future generations), and existence (knowing that the environment continues to exist).

Both are relevant to valuing changes in the environment as a result of SFS measures. They are a recognised part of policy appraisal methods in the UK, as described in HM Treasury Green Book (Annex 2), and in particular, bequest and altruism motivations are relevant under the requirements of the Well-being of Future Generations (Wales) Act 2015. However, it should be noted that this economic value framework excludes ‘intrinsic value’, which relates to the value of a species or the environment in itself, rather than values attributed through peoples’ preferences.

[8] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

[9] Ozdemiroglu, E. & Hails, R. (eds), 2016. Demystifying Economic Valuation, Valuing Nature Paper VNP04. https://valuing-nature.net/demystifying-economic-valuation-paper

2.2.2 Identifying values for Sustainable Farm Scheme design

Valuing any given public good outcome will involve identifying the change in the outcome due to the SFS measures (biophysical indicators) and value of that change (economic value evidence). The following three broad approaches give a basis for the monetary assessment of economic values associated with public goods generated by SFS measures:

- **The value of the welfare generated:** Data sources for this are individuals' behaviours in actual and surrogate markets[10]; and individuals' preferences (as measured through survey-based stated preference methods). An example is people's preferences for higher quality of water left in the environment and any additional welfare-generating activities (e.g. water-based recreation) made possible through activities that the Sustainable Farming Scheme (SFS) scheme triggers.

- **The value of the damage avoided:** For example trees and other vegetation cover filter air, reduce air pollution and avoid human health and other damages that would have been caused by air pollution. Data for this category would come from market data (if the damaged goods and services are marketed) or surrogate market data (e.g. such as medical costs being used as proxy for the avoided cost of human health damage).

- **Alternative cost avoided**: assess whether and how a given benefit from a natural capital asset could be provided by, say, manufactured capital. If natural capital is maintained, the cost of manufactured capital would be avoided – assuming of course substitution between the capitals. For example, reducing water pollution would save water treatment costs.

It is important to recognise here that the SFS could be the delivery mechanism for public goods that are the topic of other government policies (e.g. improving health, wellbeing). There are gaps in evidence, practical understanding and data which make it impossible to estimate the economic value of all public goods or changes in their provision. Therefore, decisions should not be based solely on outcomes that can be valued.

Furthermore, there is a policy and scheme design trade-off between simplicity in payment levels and reflecting the geographic variation in benefits from some environmental outcomes. Payment levels for key environmental outcomes are very sensitive because they will impact on the spatial distribution of agricultural support under the SFS. The Welsh Government are investigating this in ongoing work to estimate the economic impacts of the proposed SFS (Welsh Government, pers com, November 2020). However, the alternative of not using an outcome and value based approach is that decisions will still be based on value judgements, but implied ones that cannot be as readily scrutinised. For more detail on economic valuation methods and their application in policy decision-making, see ERAMMP Report-27.

Values for the changes in public goods (discussed in section 4), plus values for changes to private goods, together indicate an economic measure of the impact on human welfare. As well as the environmental public goods examined, the SFS is also aiming to support other outcomes in terms of wellbeing (health, education, prosperity, culture), Welsh language, landscape and heritage. Many of these are interrelated with air and water pollution, cultural, access, and other outcomes from farming practices. Identifying values is NOT the same as recommendation payment rates, which must consider these synergies and overlaps between actions (see Section 5), as well as available resources and value for money, when interpreting values.

[10] Surrogate markets do not trade public goods, but through them individuals could express their preferences for the public goods. For example, travel cost method uses cost of travel and time to value the welfare gain from recreational visits. For further discussion of valuation approaches, see ERAMMP Report-27 (Annex D) www.erammp.wales/27

3 Draft Logic Chains

This section provides draft logic chains and identifies social values a range of ecosystem services and outcomes from the SFS consultation:

1. Air Quality
2. Climate regulation: Increased tree cover; Saltmarsh; Peatland; Grassland
3. Decarbonisation
4. Flood risk mitigation
5. Water quality
6. Resilient ecosystems and species recovery
7. Animal health and wellbeing
8. Soil husbandry
9. Direct value of biodiversity

The different logic chains are defined according to the policy issues in the SFS consultation. This means that there are some differences between logic chains that are based on ecosystem services (e.g. carbon sequestration) and those based on management measures (e.g. soil husbandry). Each logic chain is accompanied by supporting notes. These include relevant public goods and methods to identify the value of these to wider society (societal value). The application of the relevant valuation evidence for these public goods is then discussed in Section 4 and interpretation of values is discussed in Section 5.

3.1 Air Quality – Reduced Agricultural Emissions

Agriculture emissions of gases (e.g. ammonia) impact air quality. This has consequences for human health and ecosystems. A logic chain for how SFS measures could help reduce emissions of air pollutants is shown in Figure 3.1. The steps in the logic chain are described in Table 3.1. A range of co-benefits are produced, including reduced carbon emissions.

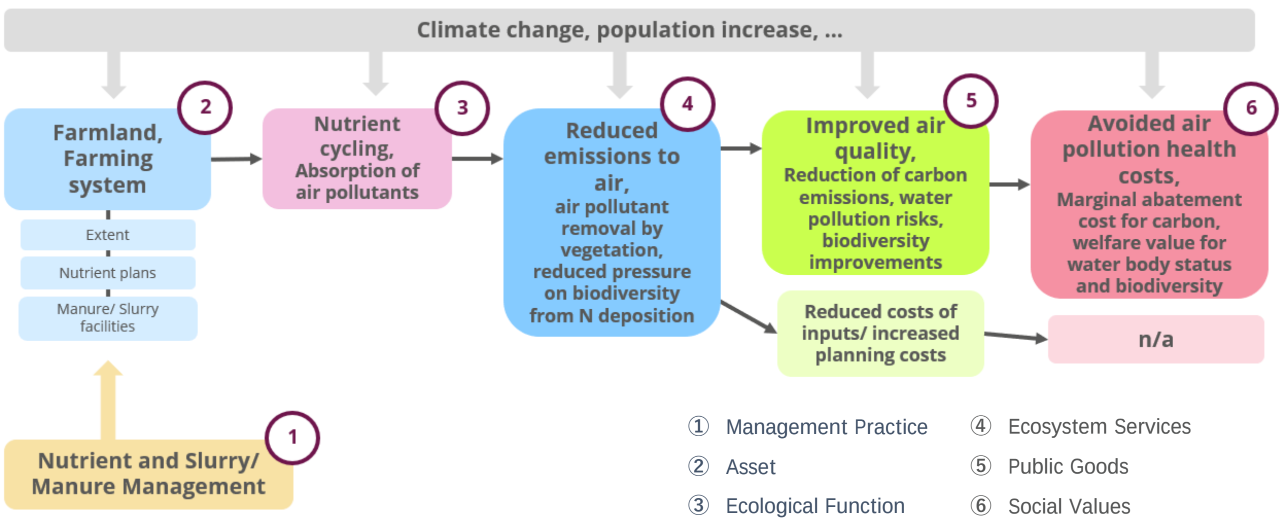

Figure 3.1 Air quality logic chain

Table 3.1 Overview of steps in air quality logic chain

Step	Explanation	Other benefits	Indicators	Confidence
1	***Management Practice*: Nutrient management planning to ensure correct quantities are applied at the right time, reducing ammonia emissions. Targeted application of fertiliser and effective storage of manure and slurry to minimise exposure to the atmosphere, reducing ammonia emissions.		Areas of farms under nutrient management plans. Monitoring of implementation of plans. Number and value of investments in manure and slurry stores.	
2	***Asset***: The key asset is the farming system: areas under different production (extent); levels of nutrients in soils and how they are stored/applied (condition); and proximity to people who face health risks (location). The extent and biodiversity of soils under production regimes that generate risks is also relevant.		Area, type and condition of agricultural production processes subject to management measures. Plant diversity, soil health. Location relative to those affected.	
3	***Ecological Functions***: The characteristics of the asset (extent, condition and location) and ecological processes in soils determine the emissions to air from farming systems.			
4	***Ecosystem Services:*** Cycling of nutrients within soil biota and plant communities can mitigate emissions to air.	Good nutrient and slurry/ manure management also: - Reduces leaching/ runoff of nutrients from farmland reducing risks to water quality - Increases ability of farmland to support plant species diversity. - Reduces emissions of GHGs from manures.	Reductions in emissions from agricultural systems. Rate of nitrogen absorption into plant communities.	
5	***Public Goods:*** Reduction in air pollution and associated impacts on human health and ecosystems.	Reduced impacts of nutrient leaching runoff/ leaching on water bodies, improving their condition. Improved ecological communities in water bodies and farmland, and semi-natural habitats. Reduced pressure on biodiversity from N deposition.	Health benefits depend on amount of air pollutant reduction and population who would have been exposed to it. Reduced ecological impact on N-sensitive plant communities.	
6	***Social Values:*** Air quality improvements can be valued based on avoided health costs from air pollution.	Water body status can be valued (see 3.3). Improved ecological communities can be valued in priority habitats (see 3.6). Private value to farmers from more efficient use of fertiliser/ nutrients.	Air pollutant reduction: health benefits per tonne of emissions avoided are robustly modelled (e.g. Jones et al. 2019[11]). Local variation with farm management/ woodland uncertain.	

[11] Jones, L. et al. (2019). ERAMMP Report-8, Annex 8: Improving Air Quality and well-being. ERAMMP Report to Welsh Government (Contract C210/2016/2017) (CEH NEC06297)

Step	Explanation	Other benefits	Indicators	Confidence
Notes	Impacts of ammonia on human health depend on dispersal of pollutants and populations exposed to them.	Better nutrient management likely to be correlated with reduced carbon footprint of farm system (e.g. through reduced purchases of chemical fertilisers/ feed).	Relevant air pollutant valuation processes are identified in Defra's ENCA guide[12], and widely used in UK policy appraisal.	

3.2 Climate regulation

Carbon sequestration takes place in different habitats in rural Wales, including woodland, saltmarsh, peatland and grassland. It has global benefit in efforts to combat climate change, as recognised in Welsh Government Targets and the UK's net zero target by 2050[13]. Each of these habitats is covered in Section 3.2.1 – 3.2.4 and the following 4 sections. In all logic chains, it is assumed good practice is applied, e.g.

3.2.1 Carbon sequestration – Increased Tree Cover

A logic chain for how SFS measures could help sequester carbon in woodland is shown in Figure 3.2. The steps in the logic chain are described in Table 3.2. This logic chain is based on a well-established understanding of climate mitigation actions, and a range of co-benefits from woodland creation. Some of these co-benefits, such as for landscape and biodiversity, are dependent on forest design and species composition. These co-benefits and forest design issues are discussed in detail in the National Forest evidence pack[14].

This logic chain assumes good practice is applied (e.g. no tree planting on peat, avoiding monocultures in sensitive landscapes). There can be flexibility for woodland delivery, which can influence the benefits realised, for example a wide range of private and social benefits can be provided by agro-forestry measures, hedgerows and shelter belts[15].

This logic chain illustrates that the social value of climate regulation is dependent on the preceding steps in the logic chain. To maximise the climate regulation benefits, SFS practice (e.g. increased tree cover) must be tailored to maximise the level of carbon sequestration; such as planting more woodland (i.e. increasing the extent of the asset) or selecting trees with the highest sequestration potential (i.e. altering species composition or age structure). However, this may lead to trade-offs with benefits from other ecosystem services, such as landscape amenity and biodiversity. Woodland planting and selecting tree species should also take account of resilience to climate change, pests and diseases.

The carbon sequestration potential of increasing tree cover depends on the species of tree planted, planting rates and management practices[16]. The yield class of trees, which considered growth rates and productivity, impact the profiling of carbon sequestration. The Woodland Carbon Code[17] considers tree spacing and tree species in the baseline assessment.

[12] Enabling Natural Capital Accounting (ENCA) (Defra, 2020)
[13] Available at: https://gov.wales/written-statement-response-committee-climate-changes-net-zero-report
[14] Beauchamp, K., et al. (2020). ERAMMP Report-32: National Forest in Wales - Evidence Review. Report to Welsh Government (Contract C210/2016/2017)(UKCEH 06297)
[15] Available at: https://erammp.wales/en/r-forest-evidence
[16] Available at: https://www.theccc.org.uk/wp-content/uploads/2018/11/Land-use-Reducing-emissions-and-preparing-for-climate-change-CCC-2018.pdf
[17] Available at: https://www.woodlandcarboncode.org.uk/

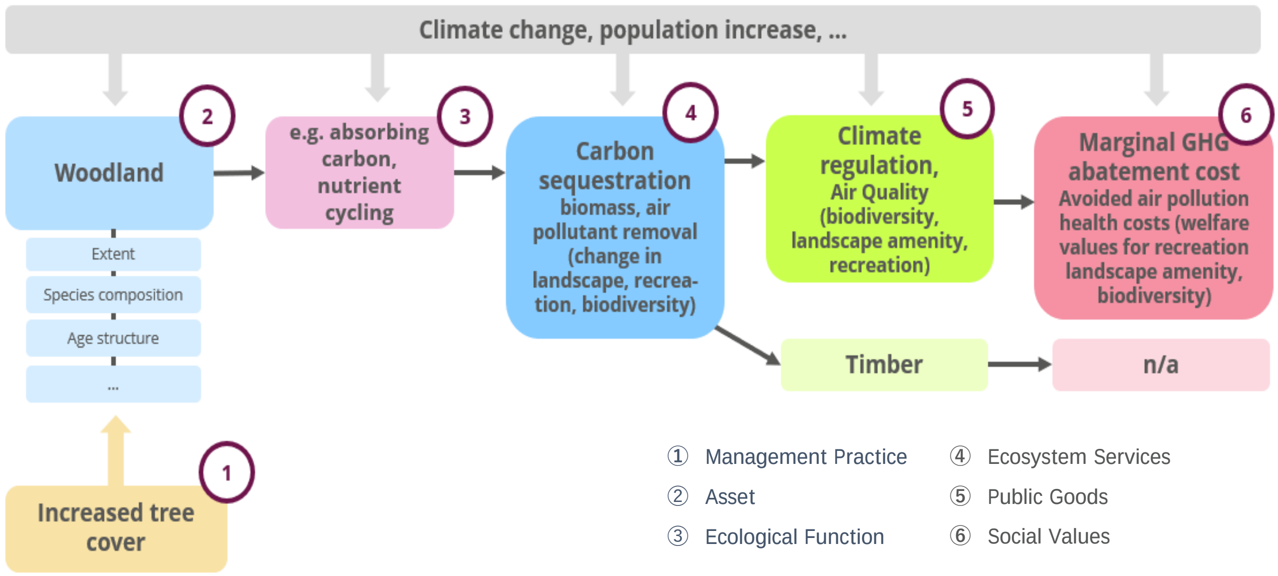

Figure 3.2 Woodland carbon sequestration logic chain

Table 3.2 Overview of steps in woodland carbon sequestration logic chain

Step	Explanation	Other benefits	Indicators	Confidence
①	*Management Practice:* SFS measure: Increased tree cover - establishing trees on an area of land.		Area of land with new tree planting	●
②	*Asset*: How increased tree cover impacts that area of land, or asset, depends on the quantity of woodland planted (extent); the types and condition of trees plants (condition); and where the trees are planted (location).		Area, type and condition of trees. Location in the natural environment and relative to beneficiaries.	●
③	*Ecological Functions*: The characteristics of the asset (extent, condition and location) underpin the ecological functions that determine the rate of carbon sequestration in biomass and soil, and potential timber production and biodiversity value. All woodland provides air pollutant removal benefits. Factors such as habitat connectivity influence the resilience of biodiversity co-benefits.			●
④	*Ecosystem Services*: Carbon sequestration is the removal of carbon dioxide from the atmosphere. The level of carbon sequestration and	Air pollutant removal by woodlands improves air quality. Depending on extent, condition and location, afforestation can increase or decrease biodiversity, landscape	Rate of carbon sequestration: average for UK woodland is 5.7 $tCO_2e/ha/yr$[18] (can differentiate by type of woodland). Impact depends on preceding land use.	●

[18] Estimated based on area of UK woodland (Forest Commission, 2017) UK natural capital accounts: 2019 (https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalaccounts/2019) and the tonnes CO2e sequestered by forestland in the UK (ONS, 2019). Woodland Area, Planting and Publicly Funded Restocking. (https://www.forestresearch.gov.uk/documents/3176/wapr2017.pdf)

Step	Explanation	Other benefits	Indicators	Confidence
	timber production depends on the conditions at the planting location, number and type of trees planted and management practices.	amenity, flood risk, water quality and recreation benefits. Recreation activity is also dependent on public access.	Rates of air pollutant removal by woodland depend on pollutant levels at a location. Flood and water quality regulation indicators are location-specific.	
⑤	***Public Goods***: Climate regulation is a public good. The size of the benefit relates to the amount of carbon sequestered. Some woodland types can give private timber values.	Water quality improvement, landscape amenity, biodiversity, flood risk reduction and recreation benefits are public goods.	Impact on GHG emissions. Landscape amenity – number of residents and visitors to an area. Recreation – number of visitors to accessible semi-natural green space (estimated from ORVal[19]). Health benefits from air pollutant removal depend on population who would have been exposed to the pollution.	●
⑥	***Social Values***: The social value of climate regulation could be valued based on the climate change damage avoided, or on alternative costs avoided. Recommended approach uses the UK Central Government Carbon Price – the marginal abatement cost (i.e. the cost of reducing one more unit of pollution).	There are no robust UK values specifically for landscape amenity and biodiversity benefits. Recreation benefits, if present, can be estimated based on the welfare value per visit. This requires the expected number of visits to be estimated. Flood risk reduction – see Table 3.7. Water quality improvements – see Table 3.8. Air quality improvements can be valued based on avoided health costs from air pollution.	Carbon: Marginal abatement cost £74 per tCO_2e in 2022 (2020£) (escalating). Recreation: value of visits from ORVal tool, or £3.89 per visit from Sen et al (2014)[20]. Air pollutant removal: health benefits per ha woodland by Local Authority area from UKCEH-eftec tool[21].	●
Notes	There are trade-offs between maximising the carbon sequestration benefits and provision of landscape amenity, biodiversity and recreation.	Values are available for the overall benefits of woodlands (bundled goods), but using these results in latest valuation evidence, such as the on the value of carbon sequestration, being ignored.	These values are identified in Defra's ENCA guide, and widely used in UK policy appraisal. Carbon values are being revised to align to the 2050 net zero carbon target.	

[19] https://www.leep.exeter.ac.uk/orval/
[20] Sen, A et al. (2014) Economic assessment of the recreational value of ecosystems: Methodological development and national and local application. Environmental and Resource Economics, 57(2), 233-249.
[21] https://shiny-apps.ceh.ac.uk/pollutionremoval/

3.2.2 Carbon sequestration – Saltmarsh

Saltmarsh habitats sequester a significant amount of carbon – carbon is absorbed through the vegetation growing on saltmarsh and sequestered in the layers of deposited sediment. Management practices, including seal wall realignment and sediment management can improve the carbon sequestration rates in saltmarsh.

A logic chain to illustrate carbon in saltmarsh is shown in Figure 3.3. The steps in the logic chain are described in Table 3.3. This logic chain illustrates that the social value of climate regulation is dependent on the preceding steps in the logic chain. To maximise the climate regulation benefits, SFS practice (e.g. saltmarsh restoration) must be tailored to maximise the level of carbon sequestration from saltmarsh.

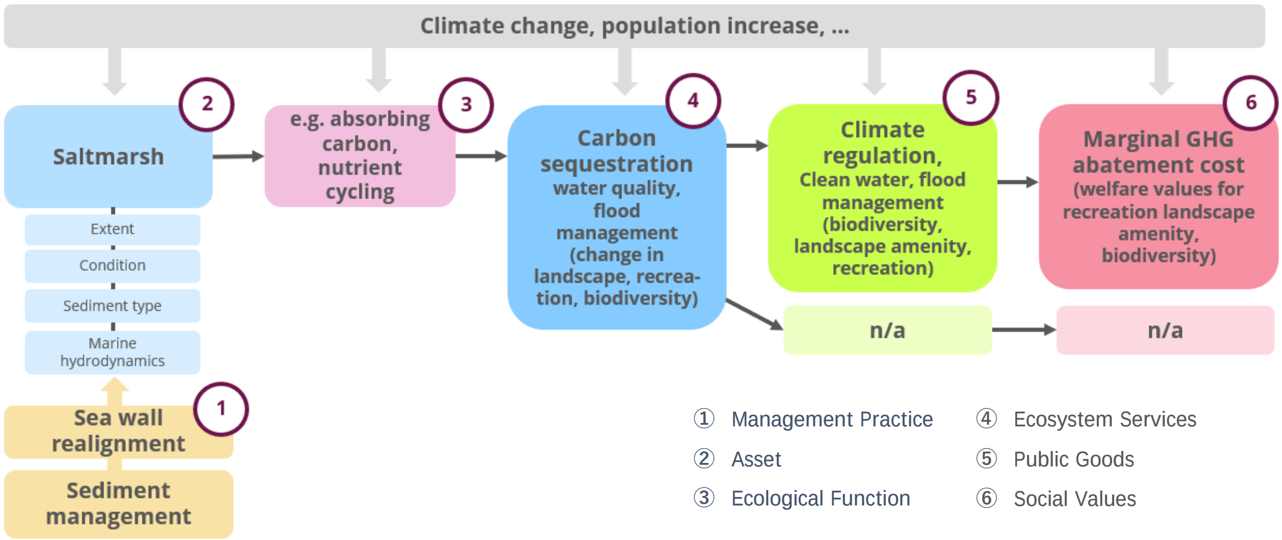

Figure 3.3 Saltmarsh carbon emissions and sequestration logic chain

Table 3.3 Overview of steps in saltmarsh carbon emissions and sequestration logic chain

Step	Explanation	Other benefits	Indicators	Confidence
①	*Management Practice:* SFS measures: - Sea wall realignment - Sedimentation management		Area of saltmarsh managed.	●
②	*Asset*: How saltmarsh management practices influence the area of land, or asset, depends on the quantity of salt marsh restored (extent); the types and condition of saltmarsh (condition); and where saltmarsh is restored (location).		Area, type and condition of saltmarsh. Location relative to beneficiaries.	●
③	*Ecological Functions*: The characteristics of the asset (extent, condition and location) underpin the ecological functions that determine the rate of carbon sequestration in saltmarsh, and biodiversity value. Factors such as habitat connectivity influence the resilience of biodiversity co-benefits.			●

Step	Explanation	Other benefits	Indicators	Confidence
④	***Ecosystem Services***: Carbon sequestration is the removal of carbon dioxide from the atmosphere. The level of carbon sequestration depends on the area and condition of saltmarsh and management practices.	Depending on extent, condition and location, saltmarsh restoration can increase or decrease biodiversity, landscape amenity, and recreation benefits. Recreation activity is also dependent on public access.	Rate of carbon sequestration: average UK saltmarsh is 2.1 – 5.2 tCO_2e/ha/yr[22]	●
⑤	***Public Goods***: Climate regulation is a public good. The size of the benefit relates to the amount of carbon sequestered.	Landscape amenity, biodiversity, and recreation benefits are public goods.	Impact on GHG emissions. Landscape amenity – number of residents and visitors to an area. Recreation – number of visitors to accessible semi-natural green space (estimated from ORVal[23]).	●
⑥	***Social Values***: The social value of climate regulation could be valued based on the climate change damage avoided, or on alternative costs avoided. Recommended approach uses the UK Central Government Carbon Price – the marginal abatement cost (i.e. the cost of reducing one more unit of pollution).	There are no robust UK values specifically for landscape amenity and biodiversity benefits. Recreation benefits, if present, can be estimated based on the welfare value per visit. This requires the expected number of visits to be estimated.	Carbon: Marginal abatement cost £74 per tCO_2e in 2022 (2020£) (escalating). Recreation: value of visits from ORVal tool, or £3.89 per visit from Sen et al (2014)[24].	●
Notes	There are trade-offs between maximising the carbon sequestration benefits and provision of landscape amenity, biodiversity and recreation.	Values are available for the overall benefits of woodlands (bundled goods), but using these data results in the latest valuation evidence, such as the on the value of carbon sequestration, being ignored.	These values are identified in Defra's ENCA guide, and widely used in UK policy appraisal. Carbon values are being revised to align to the 2050 net zero carbon target.	

[22] http://publications.naturalengland.org.uk/file/6198251661295616; Cannell, M.G.R., Milne, R., Hargreaves, K.J., Brown, T.A.W., Cruickskank, M.M., Bradley, R.I., Spencer, T., Hope, D., Billett, M.F., Adger, N. and Subak, S. (1999). National Inventories of Terrestrial Carbon Sources and Sinks: The U.K. Experience. Climate Change, 42, p.505-530; https://www.ons.gov.uk/economy/environmentalaccounts/methodologies/scopingukcoastalmarginecosystemaccounts#deep-dive-regulating-services

[23] https://www.leep.exeter.ac.uk/orval/

[24] Sen, A et al. (2014) Economic assessment of the recreational value of ecosystems: Methodological development and national and local application. Environmental and Resource Economics, 57(2), 233-249.

3.2.3 Carbon sequestration and storage - Peatland

Peatlands store carbon but, if in a degraded condition, are a source of greenhouse gas (GHG) emissions. A logic chain to illustrate carbon in peatlands is shown in Figure 3.4. The steps in the logic chain are described in Table 3.4. This logic chain illustrates that the social value of climate regulation is dependent on the preceding steps in the logic chain. To maximise the climate regulation benefits, SFS practice (e.g. peatland restoration) must be tailored to minimise the level of GHG emissions from peatlands.

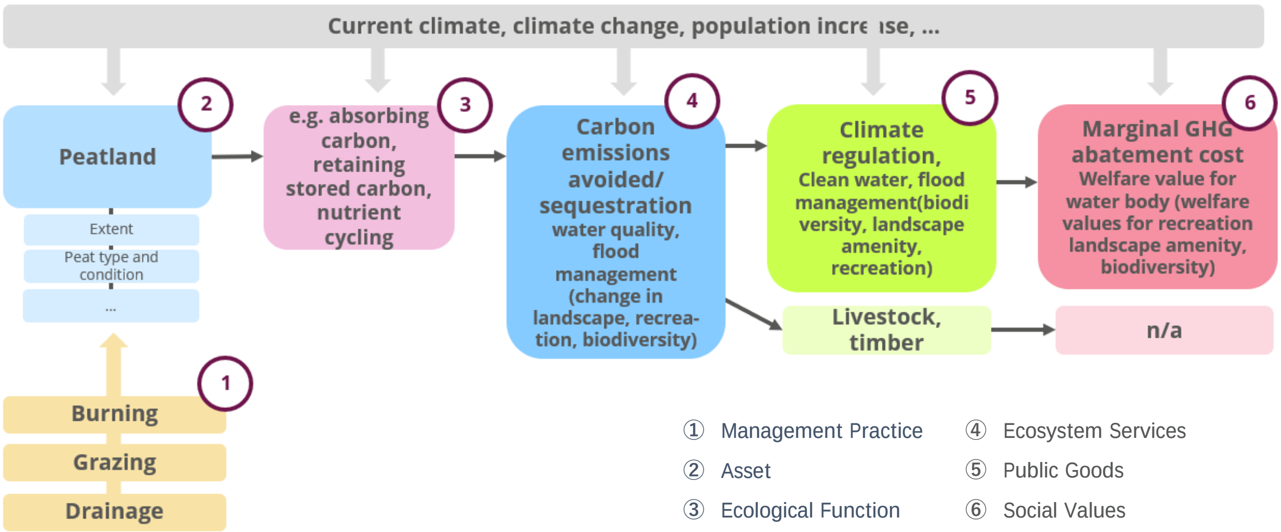

Figure 3.4 Peatland carbon emissions and sequestration logic chain

Table 3.4 Overview of steps in peatland carbon emissions and sequestration logic chain

Step	Explanation	Other benefits	Indicators	Confidence
①	*Management Practice:* SFS measure: Peatland restoration – restoring degraded peatland including prescribed burning, reduced grazing and drainage.		Area of peat restored. Area and degradation level of degraded peatlands.	●
②	*Asset*: How the peatland restoration impacts that area of land, or asset, depends on the quantity of peatland restored (extent, depth); the condition and type of peat (condition).		Area, type and condition of peat. Location relative to beneficiaries.	●
③	*Ecological Functions*: The characteristics of the asset (extent, condition and location) underpin the ecological functions that determine the rate of carbon emitted from peat, and biodiversity value.	Peatland can also provide recreation, water quality and flood management benefits. Factors such as habitat connectivity influence the resilience of biodiversity co-benefits.		●
④	*Ecosystem Services*: Peatlands store significant carbon. Degraded peatlands dry out, emitting stored carbon. Restoration rewets peatlands and avoids these emissions. Rewetting may lead to additional methane emissions,	Depending on extent, condition and location, peatland restoration can increase water quality biodiversity, landscape amenity, and recreation	Peatland carbon emissions range between 23.8 to 1.08	●

Step	Explanation	Other benefits	Indicators	Confidence
	which is a GHG, but avoided emissions result in net reductions in GHGs in the long run. Carbon sequestration is the removal of carbon dioxide from the atmosphere. The level of carbon sequestration by peatlands per ha/ yr is low relative to other habitats in the short-term.	benefits, and reduce flood risks. Recreation benefits can occur, but activity is also dependent on public access	tCO2e/ha/yr from actively eroding peat to near natural[25]. Near natural (fen) peatlands can sequester up to 0.61 tCo2e/ha/yr[26]	
5	***Public Goods***: Climate regulation is a public good. The size of the benefit relates to the amount of carbon emissions avoided. Some peatland gives private values from livestock and timber production.	Water quality improvement, landscape amenity, biodiversity, flood risk reduction and recreation benefits are public goods.	Impact on GHG emissions. Landscape amenity – number of residents and visitors to an area. Recreation – number of visitors to accessible green space (estimated from ORVal[27]).	
6	***Social Values***: The social value of climate regulation could be valued based on the climate change damage avoided, or on alternative costs avoided. Recommended approach uses the UK Central Government Carbon Price – the marginal abatement cost (i.e. the cost of reducing one more unit of pollution).	There are no robust UK values specifically for landscape amenity and biodiversity benefits. Recreation benefits, if present, can be estimated based on the welfare value per visit. This requires the expected number of visits to be estimated. Flood risk reduction – see Table 3.7. Water quality improvements – see Table 3.8.	Carbon: Marginal abatement cost £74 per tCO_2e in 2022 (2020£) (escalating). Recreation: value of visits from ORVal tool, or £3.89 per visit from Sen et al (2014)[28].	
Notes	There are trade-offs between maximising the carbon regulation benefits, viability of current land uses, and provision of landscape amenity, biodiversity and recreation.		These values are identified in Defra's ENCA guide, and widely used in UK policy appraisal. Carbon values are being revised to align to the 2050 net zero carbon target.	

[25] https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2019-07/PC_Field_Protocol_v1.1.pdf
[26] Evans, C. (2017) Implementation of an emission inventory for UK peatlands. Report to the Department for Business, Energy and Industrial Strategy, Centre for Ecology and Hydrology, Bangor. 88 pp.
[27] https://www.leep.exeter.ac.uk/orval/
[28] Sen, A et al. (2014) Economic assessment of the recreational value of ecosystems: Methodological development and national and local application. Environmental and Resource Economics, 57(2), 233-249.

3.2.4 Carbon sequestration - Grassland

Grassland soils can sequester carbon, depending on land management practices. Sward and fertiliser management measures can increase the carbon capture potential of soils[29]. They can also benefit soil structure, and so produce other benefits, including water quality regulation, air quality regulation and flood risk mitigation. The impact of these management practices can depend on the quality of the natural asset – soil type or soil carbon content – and many external factors including climate. A logic chain for how SFS measures could help increase carbon sequestration in grassland is shown in Figure 3.5. The steps in the logic chain are described in Table 3.5.

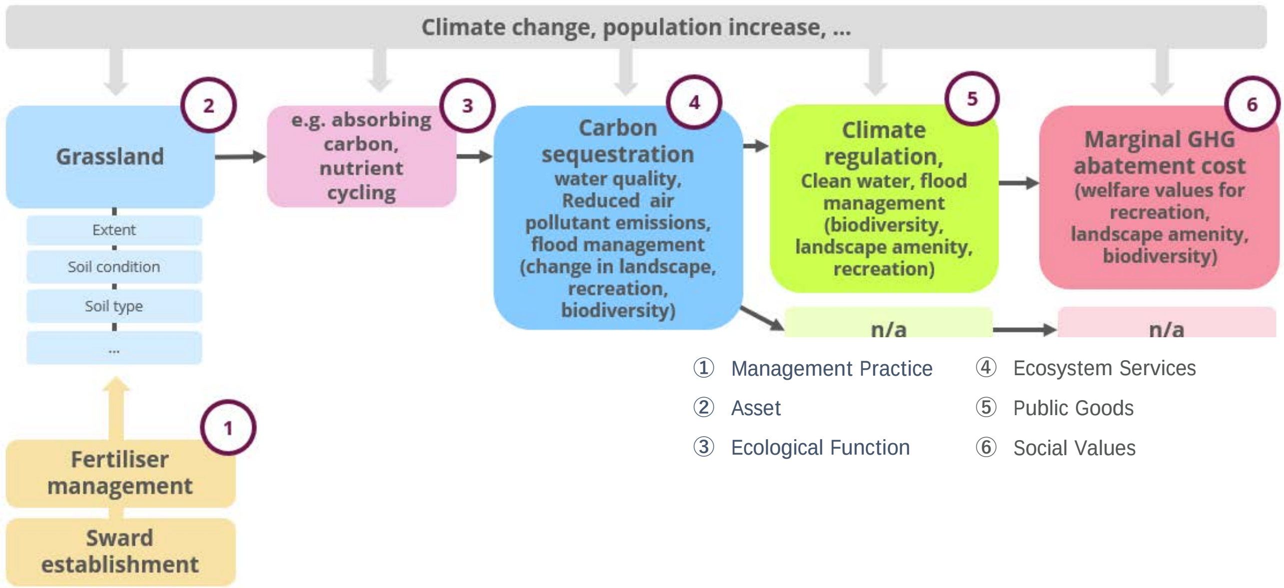

Figure 3.5 Grassland carbon sequestration logic chain

Table 3.5 Overview of steps in grassland carbon sequestration logic chain

Step	Explanation	Other benefits	Indicators	Confidence
①	*Management Practice*: Increase carbon sequestration through appropriate habitat management and fertiliser application on improved land: - Improve fertiliser management - Sward establishment and maintenance - Grazing management		Areas of farms under fertiliser management plans. Monitoring of implementation of plans. Number and condition of swards.	●
②	*Asset*: How the measures impact carbon sequestration depends on the use of fertiliser and sward plans in the farming system.		Area, type and condition of farmland under relevant plans.	●
③	*Ecological Functions*: The characteristics of the asset (extent, condition and location) underpin the	Grassland can also provide recreation, water quality and flood management benefits. Factors such as habitat		●

[29] See: Report-2 Annex-2: Sward Management. www.erammp.wales/2

Step	Explanation	Other benefits	Indicators	Confidence
	ecological functions that determine the rate of carbon sequestration in soils.	connectivity influence the resilience of biodiversity co-benefits.		
④	***Ecosystem Services***: Carbon sequestration is the removal of carbon dioxide from the atmosphere. The level of carbon sequestration depends on the type of soil, current soil carbon content, management practices and climate.	Depending on extent, condition and location, grasslands can increase water quality biodiversity, landscape amenity, and recreation benefits, and reduce flood risks.	Rate of carbon sequestration in grasslands unclear: some data suggests average for UK grassland is 0.4 – 0.6 tCO2e/ha/yr[30] Lacking IPCC data.	🔴
⑤	***Public Goods***: Climate regulation is a public good. The size of the benefit relates to the amount of carbon sequestered.	Water quality improvement, landscape amenity, biodiversity, flood risk reduction and recreation benefits are public goods.	Flood risk reduction – see Table 3.7. Water quality improvements – see Table 3.8.	🟡
⑥	***Social Values***: The social value of climate regulation can be valued based on the climate change damage avoided, or on alternative costs avoided. Recommended approach uses the UK Central Government Carbon Price – the marginal abatement cost (i.e. the cost of reducing one more unit of pollution).	There are no robust UK values specifically for landscape amenity and biodiversity benefits. Recreation benefits, if present, can be estimated based on the welfare value per visit. This requires the expected number of visits to be estimated. Flood risk reduction – see Table 3.7. Water quality improvements – see Table 3.8.	Carbon: Marginal abatement cost £74 per tCO_2e in 2022 (2020£) (escalating). Recreation: value of visits from ORVal tool, or £3.89 per visit from Sen et al (2014)[31].	🟡
Notes				

[30] Christie et al (2011); Soussana et al. (2010)
[31] Sen, A et al. (2014) Economic assessment of the recreational value of ecosystems: Methodological development and national and local application. Environmental and Resource Economics, 57(2), 233-249.

3.3 Decarbonisation

Greenhouse gas (GHG) emissions arise from use of farming inputs, directly (e.g. from machinery powered by fossil fuels and livestock) and indirectly (e.g. from electricity use and in production of other inputs such as agro-chemicals) as a result of farming practices. A logic chain for how SFS measures could help reduce GHG emissions is shown in Figure 3.6. The steps in the logic chain are described in Table 3.6.

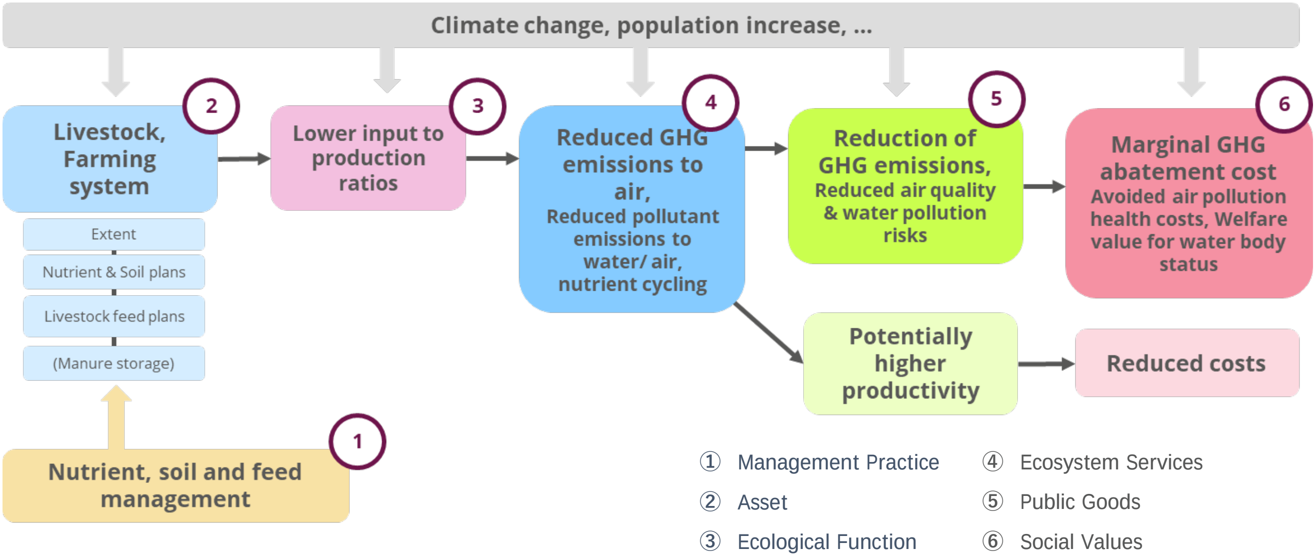

Figure 3.6 Decarbonisation logic chain

Table 3.6 Overview of steps in decarbonisation logic chain

Step	Explanation	Other benefits	Indicators	Confidence
①	*Management Practice*: Reduced GHG emissions: (i) directly from farming: - Nutrient management to minimise exposure of manures and other inputs to the atmosphere, reducing GHG (nitrous oxide and methane) emissions - Good soil management reducing GHG emissions from damaged peatland - Management using different feed types and supplements to reduce GHG emissions by animals and livestock. Improves productivity by producing the same output with fewer animals, meaning less GHG emissions. (ii) indirectly from farming supply chains - Nutrient management reducing mineral fertiliser usage, AND Soil husbandry reducing use of nitrogen (N) fertiliser, cutting GHG emissions from production processes.		Areas of farms under nutrient and/or soil management plans. Monitoring of implementation of plans. Dissemination and adoption of lower carbon livestock feeding regimes. Mineral fertiliser usage.	● (green)
②	*Asset*: How the measures impact GHG emissions depends on the use of soil/nutrient/feed plans in the farming system, and the supply chains for inputs. Benefits reflect improvements in sub-optimal current practice, or technological advances.		Area, type and condition of farmland under relevant plans.	● (amber)
③	*Ecological Functions*: Only indirectly relevant, as GHG emissions are primarily the result of farming practices. Lower ratios of relevant inputs to agricultural outputs, soil husbandry that reduces the use of			● (amber)

Step	Explanation	Other benefits	Indicators	Confidence
	nitrogen fertiliser will rely on ecological functions to provide nitrogen to plants.			
④	*Ecosystem Services*: Processes that enable lower ratios of relevant inputs to agricultural outputs, including nutrient cycling in soils and plants.	Reduced pollutant emissions to water/ air, nutrient cycling	Farm inputs that directly affect GHG emissions.	●
⑤	*Public Goods*: Reduction of GHG emissions is a public good. The size of the benefit relates to the amount of emissions avoided. Lower inputs per output of production can reduce private farm costs.	Reduced impacts of water/ air pollutants	Productivity of farming (output to input ratio, output to direct & indirect GHG emission ratio)	●
⑥	***Social Values***: The social value of climate regulation can be valued based on the climate change damage avoided, or on alternative costs avoided. Recommended approach uses the UK Central Government Carbon Price – the marginal abatement cost (i.e. the cost of reducing one more unit of pollution).	Reduction in air pollution and associated impacts on human health. Reduced impacts of nutrient leaching runoff/ leaching on water bodies, improving their condition. Improved ecological communities in water bodies and farmland.	Carbon: Marginal abatement cost £74 per tCO_2e in 2022 (2020 prices) (escalating). Recreation: see 3.2 Air pollutant reduction: see 3.1. Water quality: see 3.5.	●
Notes	These values are identified in Defra's ENCA guide, and widely used in UK policy appraisal. Carbon values are being revised to align to the 2050 net zero carbon target.			

3.4 Flood risk mitigation

Flood risk is determined by a variety of factors including rainfall patterns, catchment topography and habitats, and location and property assets and flood risk management measures on floodplains[32]. Flood risks are expected to increase with climate change[33]. A logic chain for how SFS measures could help reduce flood risk is shown in Figure 3.7. The steps in the logic chain are described in Table 3.7.

[32] See: ERAMMP Report-9 Annex-9: Flood Mitigation www.erammp.wales/9

[33] The UK Climate Change Risk Assessment 2017 Evidence Report presents compelling evidence that climate change may lead to increases in heavy rainfall and significantly increased risks from fluvial and surface flooding by mid-century (UK Climate Change Risk Assessment, 2017).

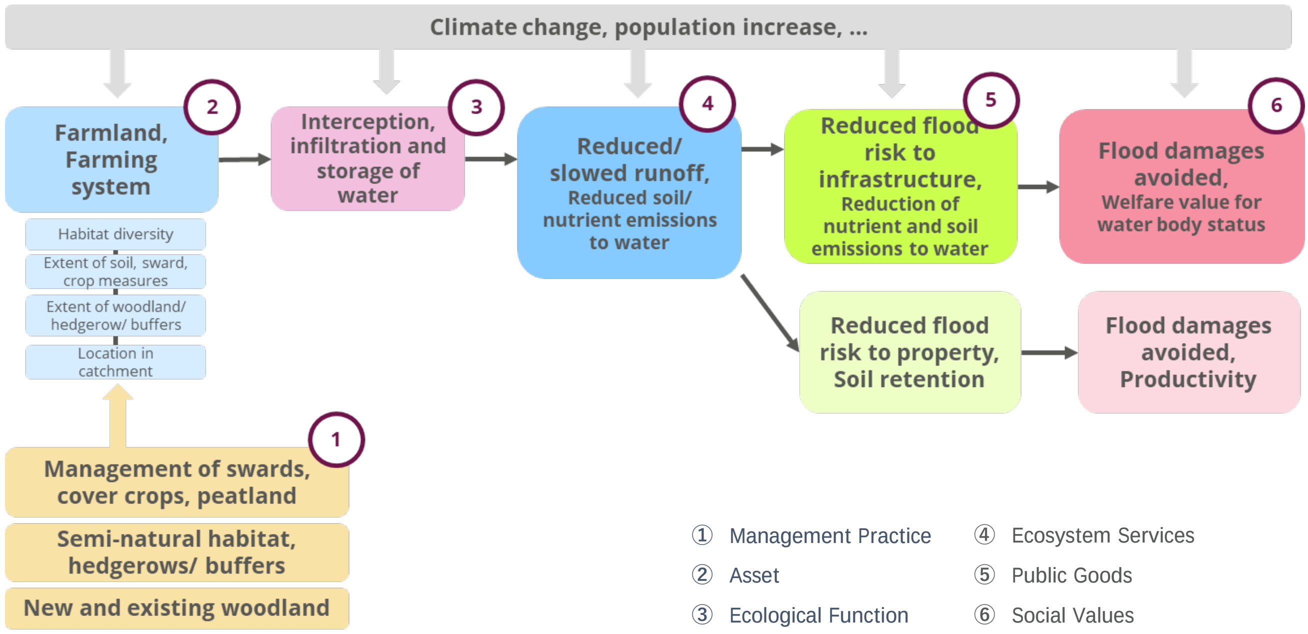

Figure 3.7 Flood Risk Mitigation logic chain

Table 3.7 Overview of steps in flood risk mitigation logic chain

Step	Explanation	Other benefits	Indicators	Confidence
①	*Management Practice*: A variety of actions on farmland can mitigate flood risk: - Use of sward management and cover cropping, and peatland soil management can increase potential infiltration rates and water retention on farmland. - Semi-natural habitat management creates improved structural diversity, and establishing hedgerows and other buffers across the slope and in riparian zones, both slow water run-off. - Farm woodland and hedgerows, and woodland creation improves water interception by improving soil structure. - Farmland on floodplains can be used to store water and reduce flood risk to downstream floodplain settlements		Area of land under relevant management measures.	●
②	*Asset*: Habitat diversity and condition (roughness) influence ecological functions. Extent and condition of soil, sward and crops. Location in catchment relative to slope, waterbodies and other assets influences functions.		Area, type and condition of habitats. Extent and condition of soil, sward and crops. Location of assets in catchment and relative to beneficiaries.	●
③	*Ecological Functions*: Ability of soils and habitats to intercept and infiltrate rainfall, slowing and reducing flows into water courses. Storage capacity of floodplains during extreme events. Greater habitat diversity and patch dynamics = greater surface roughness.			●

<table>
<tr><th>Step</th><th>Explanation</th><th>Other benefits</th><th>Indicators</th><th>Confidence</th></tr>
<tr><td>④</td><td>Ecosystem Services: Interception, infiltration and retention of rainfall to reduce run-off to water courses.</td><td>Reduced emissions of N, P, Z from agricultural land. The level of emissions reduction depends on the area and type of management measures.</td><td rowspan="2">The role of these measures in slowing/ reducing water runoff and the consequences for downstream flood risk can be hard to measure and quantify.
Generic UK values per ha of woodland are available[34], but these have very high uncertainty when applied in individual catchments.</td><td>●</td></tr>
<tr><td>⑤</td><td>Public Goods: Flood risk reduction is both a private good (protecting private property) and a public good (reducing impacts on shared infrastructure and communities).</td><td>Water quality improvement.
Soil retention.</td><td>●*</td></tr>
<tr><td>⑥</td><td>Social Values: Flood risk mitigation – risk reduction to properties, average value per property.</td><td>The social value of water quality: See 3.5.
Soil retention increases farm productivity.</td><td>Expected flood damages can be estimated from data on property and historical flood risks.</td><td>●</td></tr>
<tr><td>Notes</td><td colspan="3">These values are identified in Defra's ENCA guide, and widely used in UK policy appraisal. See Green Book p.66 for some values and uses/limitations of (weighted) annual average damage (WAAD) estimates.
* Detailed modelling of flood risks at a catchment scale are required to support more robust evidence.</td><td></td></tr>
</table>

3.5 Water quality

Emissions of nitrates (N), phosphates (P) and sediment (Z) from agricultural land to water courses can have adverse impacts on water quality, and is one of the main pressures on freshwater quality in the Welsh Environment (along with other sources such as wastewater treatment works). A logic chain for how SFS measures could help reduce pressures on water quality is shown in Figure 3.8. The steps in the logic chain are described in Table 3.8.

[34] Forest Research (2018) https://www.forestresearch.gov.uk/research/valuing-flood-regulation-services-existing-forest-cover-inform-natural-capital-accounts/

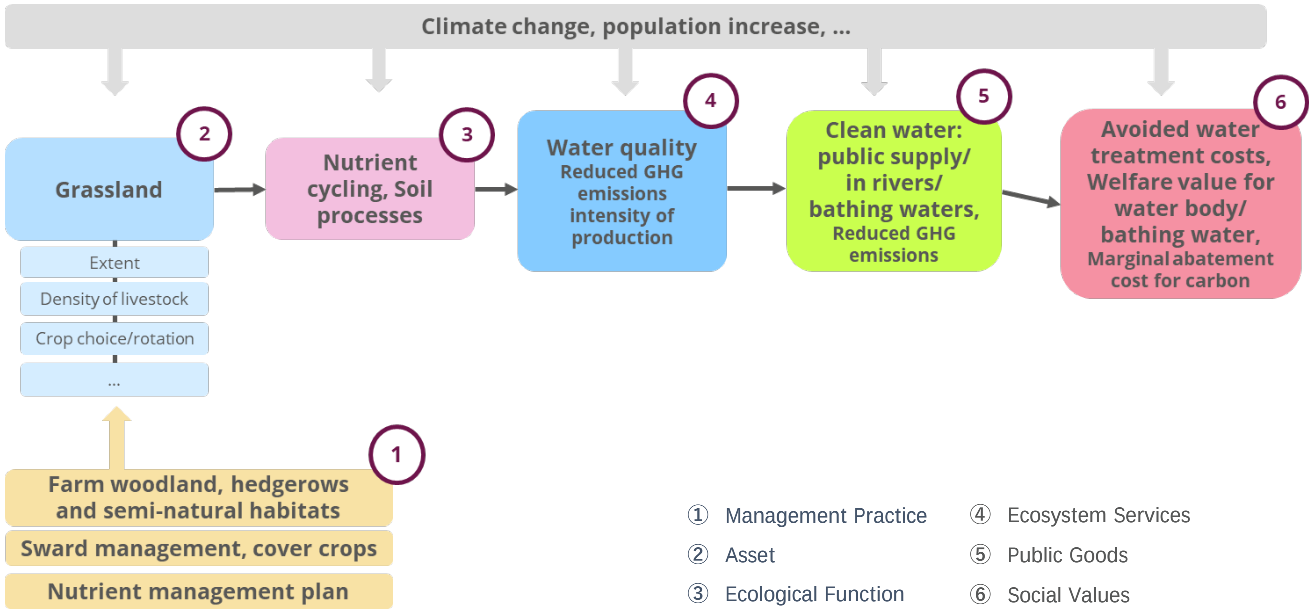

Figure 3.8 Water quality logic chain

Table 3.8 Overview of steps in water quality logic chain

Step	Explanation	Other benefits	Indicators	Confidence
①	*Management Practice*: SFS measures to support water quality include: - Semi-natural habitat management, giving runoff control measures and/or reduction in nutrient inputs and/or stocking densities - Farm woodland, hedgerows and habitat areas created across slopes and in riparian zones to increase potential for interception of pollutants - Sward management and cover cropping, and peatland soil management and all increase the ability of soil to retain nutrients and water, reducing leached nutrients and/or erosion - Effective planning of nutrient application and management ensures correct quantities are applied at the right time, reducing run-off and leaching of nitrogen, phosphorous and potassium (NPK) from soils - Effective storage of manure and slurry so they do not leach or leak into watercourses		Area of land subject to management	
②	*Asset*: How the measures impact water quality, depends on the size of area (extent), the types of measures taken, the condition of the soil (condition) and where the land is relative to water bodies (location). Livestock grazing intensity. Nutrients in soil support crop production. Slope and soil type determine erosion risk.		Area, type, location and condition of farmland subject to management measures. Location relative to waterbodies and other sources of emissions.	
③	*Ecological Functions*: The characteristics of the asset (extent, condition and location) underpin the ecological	Increased habitat diversity. Semi-natural habitat	Greater connectivity of waterbodies in good condition indicates resilience.	

Step	Explanation	Other benefits	Indicators	Confidence
	functions that determine the rate of nutrient processing and absorption into soil and the extent of leakage to water bodies. Optimum levels of nitrogen, phosphorous and potassium (NPK) in soils, reducing leaching	can buffer waterbodies.		
④	***Ecosystem Services***: Water quality is impacted by the emissions of NPK and sediment (Z) from agricultural land uses to water bodies. The level of emissions reduction depends on the area and type of management measures.	Increased habitat and species diversity	Modelling can predict changes in N, P, Z emissions from changes in agricultural practices (Farmscoper Tool - ADAS).	●
⑤	***Public Goods***: Water quality is a public good. This size of the benefit relates to the amount of water quality improvement. More efficient use of nutrients may create private value to the farmer.	Habitat and species diversity	Relating the expected change in emissions to waterbody levels of N, P, Z can be used to predict change in concentrations at water treatment works and change in Water Framework Directive (WFD) status.	●
⑥	***Social Values***: The social value of water quality could be valued based on: Damage avoided: health impact due to coming into contact with polluted water. Alternative cost avoided: cost of water treatment for public supply. Welfare generated: willingness to pay for cleaner water in the environment and for use; recreational opportunities provided by cleaner water in the environment.	Value of more diverse farmland habitats – as part of a bundle of good.	Damage avoided: health incidents from drinking water are very rare in the UK. Agricultural pollutants can also affect bathing waters. Welfare generated: values from study conducted to estimate the benefits of implementing the WFD[35]. Alternative cost avoided: Chadwick et al. (2006) identify the annual values of reducing a kilogramme of pollutant in water from agricultural sources[36] .	●

[35] NWEBS (National Water Environment Benefits) values are comprised of six benefits: fish, other animals such as invertebrates, plant communities, the clarity of water, the condition of the river channel and flow of water, and the safety of the water for recreation contact. The components are weighted equally. Therefore, for example, if recreation was the only benefit of interest, a sixth of the NWEBS value is taken. NWEB vales are taken from the study: Metcalfe, P. J., et al., (2012) An Assessment of the Non-market Benefit of the Water Framework Directive to Households in England and Wales, Water Resources Research, 48 (3), as referenced in HM Treasury (2018).

[36] Chadwick, D., et al. (2006) Benefits and pollution swapping: Cross-cutting issues for catchment sensitive farming policy. Defra project WT0706, Final Report. There are uncertainties around these values as they assume that a reduction in pollutants across all water bodies are treated equally (i.e. no distinction between good quality or poor-quality water). As cited in ‘Enabling Natural Capital Accounting’ (Defra, 2020: https://www.gov.uk/guidance/enabling-a-natural-capital-approach-enca)

Step	Explanation	Other benefits	Indicators	Confidence
Notes	N and P and Z treatment costs vary, but locally specific costs should be known to water companies. WFD status values in NWEBS are a bundled good, representing several other factors in addition to water quality. Values apply when there is a change in the WFD classification (between poor, medium and good).			

3.6 Resilient ecosystems and species recovery

Resilient ecosystems and species recovery is influenced by a wide range of management measures across farmland and other habitats. Measuring the condition of habitats and species is complex. A logic chain for how SFS measures could help increase ecosystem resilience and support species recovery is shown in Figure 3.9. The steps in the logic chain are described in Table 3.9.

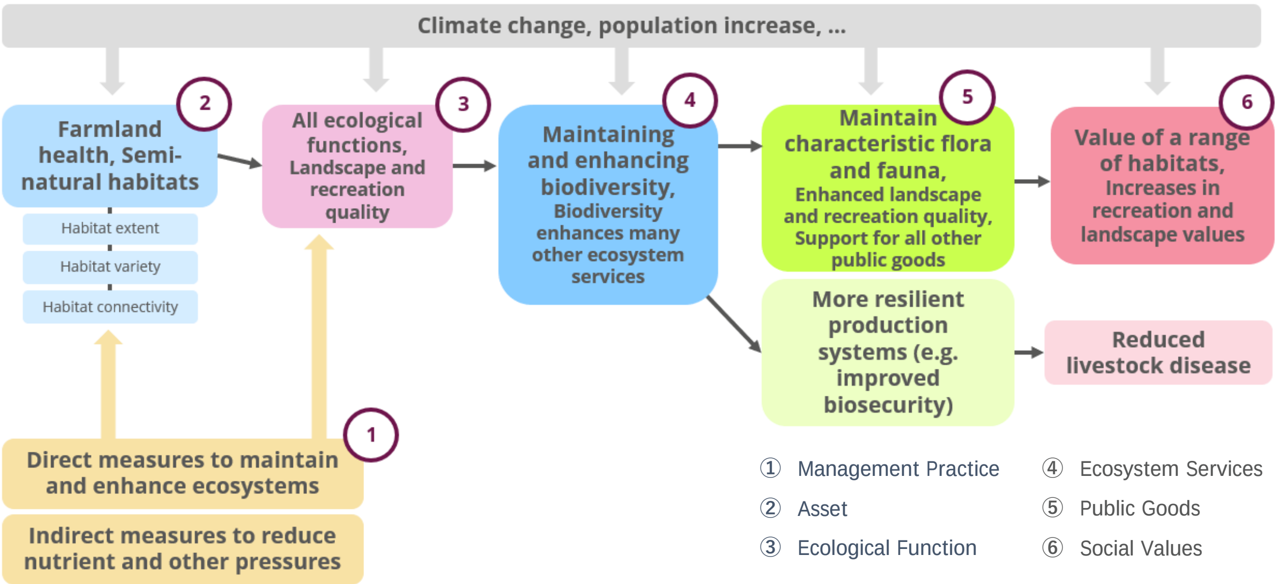

Figure 3.9 Ecosystem resilience and species recovery logic chain

Table 3.9 Overview of steps in resilient ecosystems and species recovery logic chain

Step	Explanation	Other benefits	Indicators	Confidence
①	*Management Practice*: SFS measures can directly increase habitat diversity, connectivity and /or patch dynamics, such as through: - Increasing tree cover on suitable areas of land to establish characteristic woodland. - Peatland management to improve quality and extent of habitats associated with peatlands. - Management of other semi-natural habitats, including farm woodland and hedgerows. - Creating new habitats in wide field boundaries and hedgerows for biosecurity (risk of disease spreading). SFS measures can also influence ecosystems and species through: - Farm nutrient (including fertiliser and slurry/manure)		Area of land subject to management.	●

Step	Explanation	Other benefits	Indicators	Confidence
	management, and sward management and cover cropping, to minimise pollution risk to soils and watercourses and improve habitat for soil microfauna, and potentially for pollinator species, reduce dominance of agriculturally favoured species and increase richness of characteristic species typical of semi-natural habitats (e.g. neutral grassland and hay meadows). - Animal health measures to reduce use of parasiticide which can affect non-target micro-organisms. - Managing livestock to improve sward structure for nesting birds. - Flood management measures that improves the resilience of functioning ecosystems by improving quality, scale and connectivity.			
②	***Asset***: the areas of semi-natural habitat (extent), diversity of habitat and the status of waterbodies and designated areas (condition), and their relative size and location (indicators of connectivity and patch dynamics).		Area, type and condition of semi-natural habitats, including designated habitats. Extent of measures to improve habitat for soil biodiversity. Resilience: - Semi-natural habitat connectivity - Soil erosion risk - Habitat diversity	●
③	***Ecological Functions***: The characteristics of the asset (extent, condition and location) underpin the ecological functions that determine the level of ecosystem resilience. Habitat enhancement measures that enable species recovery. Underpins functions that underpin nonvalues of market (e.g. pollination supporting food production) and non-market (e.g. carbon sequestration in soils) goods and culturally valued species whose presence and abundance defines higher quality habitat in better condition.			●
④	***Ecosystem Services***: Maintaining and enhancing biodiversity is a benefit in itself (i.e. something people value for its own sake)	Biodiversity is also an input to a wide range of other services (e.g. recreation, nutrient cycling).		●
⑤	***Public Goods***: Maintaining a variety of characteristic habitats and species contributes to other services: provisioning (e.g. via pollination); regulating (e.g. nutrient cycling); cultural (e.g. recreation) has a cultural value.	Habitat type and diversity is one (of several) determinants of recreational activity. For direct cultural value of species, see Section 3.9.	Recreation – number of visitors to a site (can be estimated from ORVal[37]). It may be possible to reflect ecosystem diversity in the expected numbers of visits.	●
⑥	***Social Values***: The social value of maintaining/ enhancing ecosystems is	Recreation benefits, if present, can be estimated based on the welfare value per visit. This	There are no widely applied UK values specifically for ecosystem resilience benefits	●

[37] https://www.leep.exeter.ac.uk/orval/

Step	Explanation	Other benefits	Indicators	Confidence
	reflected in values for habitat improvements.	requires the expected number of visits to be estimated.	per se. Values are available for biodiversity enhancement in specific contexts (see Section 4). The value of recreation visits can be estimated through ORVal.	
Notes	These values are identified in Defra's ENCA guide, and widely used in UK policy appraisal.			

3.7 Animal health and wellbeing

Animal health is defined as the physical, mental and social wellbeing of an animal. This logic chain focusses on the health and wellbeing of animals in the natural environment. It excludes other determinants of animal health, including indoor production and transportation conditions.

Heathier animals are more productive and therefore less animals are needed to produce the same output. This reduces the input costs to farmers and also leads to reduced GHGs emissions and improved air quality. Actions taken to improve animal health include animal health planning (AHP) and biosecurity. These measures also improve the resilience of ecosystems through reducing the risk of disease spreading. A logic chain for how SFS measures could help improve animal health and welfare is shown in Figure 3.10. The steps in the logic chain are described in Table 3.10.

Some aspects of animal health are a private good, as there are benefits to farmers, and ways of consumers reflecting their preferences in market purchases (based on food labelling). However, there are also several complex veterinary and public health impacts that relate to public goods (e.g. anti-microbial resistance, effects of animal medicines on biodiversity, and zoonotic diseases) that interact with the natural environment.

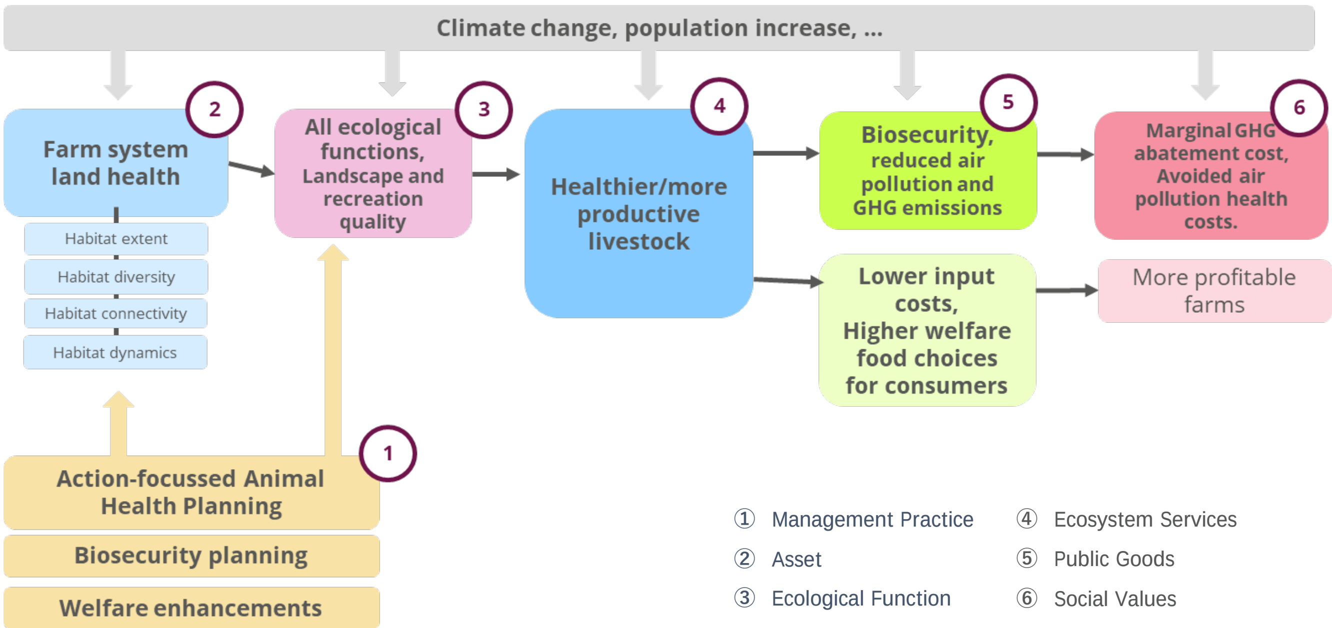

Figure 3.10 Animal health and wellbeing logic chain

Table 3.10 Overview of steps in animal health and wellbeing logic chain

Step	Explanation	Other benefits	Indicators	Confidence
①	***Management Practice***: SFS measures can directly improve animal health and welfare, such as through: - Animal Health Planning (AHP) to improve disease prevention; - Biosecurity planning to prevent diseases entering and spreading on farms; and - Welfare enhancements.		Area of land subject to management.	●
②	***Asset***: the areas of diverse (i.e. mixed grazing) agricultural habitats (extent & condition), and location (indicators of connectivity and patch dynamics).		Area, type and condition of agricultural habitats.	●
③	***Ecological Functions***: The characteristics of the asset (extent, condition and location) underpin the ecological functions that determine the level of biosecurity.			●
④	***Ecosystem Services***: The improved productivity of livestock, resulting in fewer livestock needed for the same output. Better use of veterinary medicines and a shift away from those used to treat problems (antibiotics) to those used to prevent them (vaccines), better animal welfare and safer food.	Maintaining and enhancing biosecurity is a benefit in itself. Reduced effects from veterinary medicines on species (e.g. Dung Beetles), and associated ecosystem processes (e.g. nutrient cycling) and services (e.g. water quality)[1].		●
⑤	***Public Goods***: Maintaining biosecurity from a variety of farm systems. Reduced antibiotic leakage to the environment.	Indirect from productivity: Improved air quality and reduced carbon emissions per unit outputs as a result of having more productive animals.	Reduction in incidence of animal welfare issues / diseases.	●
⑥	***Social Values***: The social value of maintaining/ enhancing farm systems is reflected in values for habitat improvements.	Values associated with animal welfare outcomes.		●
Notes	1. Wildlife Trusts Wales, pers com November 2020.			

3.8 Soil husbandry

Soil husbandry involves the maintenance and improvement of physical, chemical and biological soil health. Soil is a key natural asset for agricultural productivity, clean water, flood prevention, climate change mitigation and biodiversity. Soil provides nutrients, structure support for plants, filters water, stores carbon and provides a habitat for species.

The logic chain presented in Figure 3.11 illustrates the direct value of biodiversity. The steps to the logic chain are described in Table 3.11.

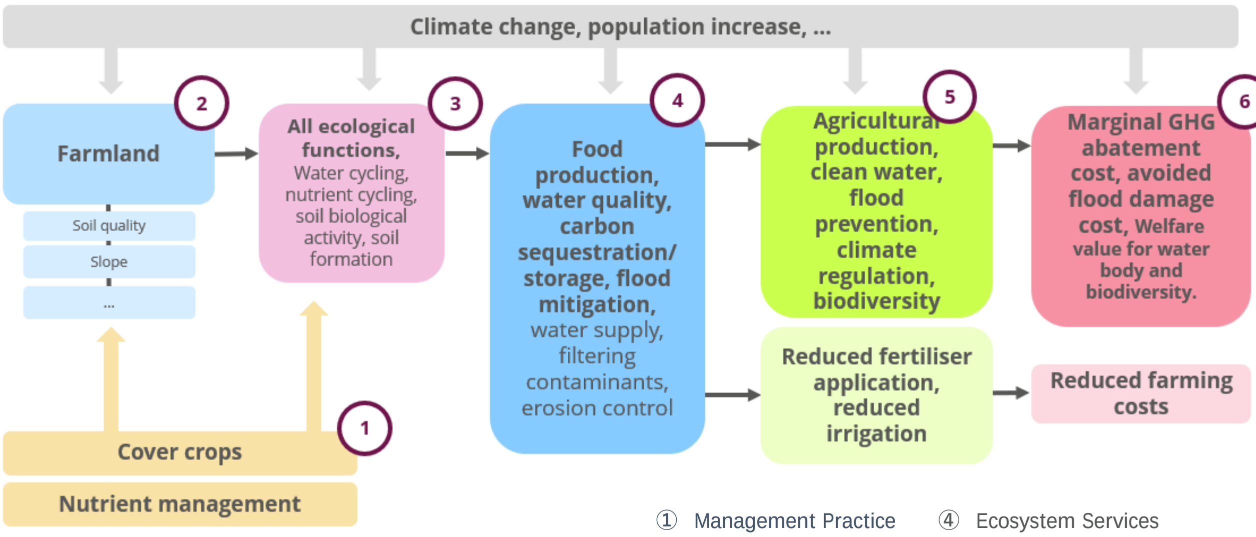

Figure 3.11 Soil husbandry logic chain

Table 3.11 Overview of steps in soil husbandry logic chain

Step	Explanation	Other benefits	Indicators	Confidence
①	*Management Practice*: SFS measures can directly improve soil health, through cover crops, tillage, nutrient management, etc.		Area of land subject to management.	●
②	*Asset*: the areas of diverse (i.e. mixed grazing) agricultural habitats (extent), soil type and quality (condition), and their location (indicators of connectivity and patch dynamics).		Area, type and condition of habitats.	●
③	*Ecological Functions*: The characteristics of the asset (extent, condition and location) underpin the ecological functions that determine the level of soil health.			●
④	*Ecosystem Services*: The improved productivity of livestock, resulting in fewer livestock needed for the same output.	Better use of veterinary medicines and a shift away from those used to treat problems (antibiotics) to those used to prevent them (vaccines), better animal welfare and safer food.		●
⑤	*Public Goods*: Agricultural production, clean water, flood prevention, climate regulation and biodiversity improvements.			●
⑥	*Social Values*: Marginal GHG abatement cost, avoided flood damage cost, Welfare value for water body and biodiversity.			●
Notes				

3.9 Direct value of biodiversity

Biodiversity encompasses multiple dimensions reflecting the variation in species (plants, animals, fungi, micro-organisms) and the habitats and natural systems that support them. It is a fundamental component of natural capital assets and core to the ecological condition and quality of ecosystems, their resilience to shocks, and capacity to support ecosystem service provision both now and into the future (see Section 3.6).

The direct value of biodiversity is an aspect of biodiversity which is the final good or service that individuals benefit from, such as nature-based recreation, or wild species conservation.

The logic chain presented in Figure 3.12 illustrates the direct value of biodiversity. The steps to the logic chain are described in Table 3.12.

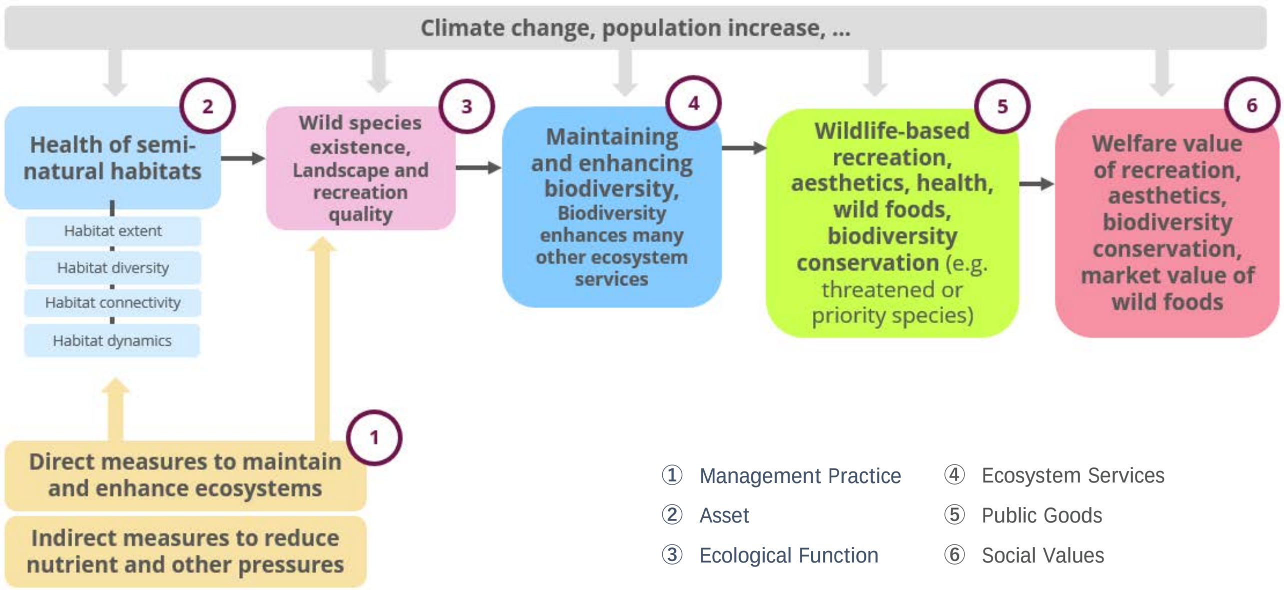

Figure 3.12 Direct value of biodiversity logic chain

Table 3.12 Overview of steps in direct value of biodiversity logic chain

Step	Explanation	Other benefits	Indicators	Confidence
①	***Management Practice***: SFS measures can directly increase habitat diversity, connectivity and /or patch dynamics, such as through: - Increased tree cover on suitable areas of land to establish characteristic woodland. - Peatland management to improve quality and extent of habitats associated with peatlands. - Management of other semi-natural habitats, including farm woodland and hedgerows. SFS measures can also influence ecosystems and species through: - Farm nutrient (including fertiliser and slurry/manure) management, and sward management and cover cropping, to minimise pollution risk to soils and watercourses and improve habitat for soil microfauna, and potentially for pollinator species.		Area of land subject to management.	● (green)
②	***Asset***: the areas of diverse (i.e. mixed grazing) agricultural habitats (extent), soil type and quality (condition), and their location (indicators of connectivity and patch dynamics).		Area, type and condition of habitats.	● (amber)
③	***Ecological Functions***: The characteristics of the asset (extent, condition and location) underpin the ecological functions that (along with external factors) determine the level of biodiversity.			● (amber)

Step	Explanation	Other benefits	Indicators	Confidence
④	***Ecosystem Services***: Maintaining and enhancing biodiversity.	Biodiversity enhances many other ecosystem services/ public goods/ social values. See Section 3.6: *Resilient ecosystems and species recovery*	Species abundance/ status Habitat condition.	●
⑤	***Public Goods***: Wildlife-based recreation, aesthetics, health, wild foods, biodiversity conservation (e.g. threatened or priority species).		There are no widely applied UK values specifically for direct biodiversity benefits per se. Values are available for biodiversity enhancement in specific contexts (see Section 4).	●
⑥	***Social Values***: Welfare value of recreation, aesthetics, biodiversity conservation, market value of wild foods.			●
Notes	Focussed on direct value. Value of other benefits not considered in this logic chain (see Section 3.6). Many external pressures including international factors influence the abundance of migratory species.			

4 UNIT VALUES

A variety of public goods are identified in the logic chains in Section 3. The valuation approaches for each are noted in the logic chain table. This section considers application of those valuation approaches to potential SFS outcomes in more detail.

As mentioned in Section 2.2.2, there are three forms of the basis of value that can be used to undertake a monetary assessment of economic values associated with public goods generated by SFS measures – value of welfare generated, value of damage avoided, and alternative cost avoided. Market price data is the most pragmatic starting point for analysis – where markets exist – as such data is readily available. Where there are no markets, primary valuation research is undertaken to create the necessary data.

Where decisions that need economic value evidence are many and similar, conducting primary research for each is not necessary. In these cases, the focus should be on making the best use for existing evidence. The process of reviewing available evidence, selecting the most suitable estimates, and adjusting them is called 'value transfer'. The adjustments would be to account for differences between the original studies and the context in which they are to be applied – for example adjusting for population sizes, wealth, and differences in ecosystems.

The simplest type, unit transfer, directly applies an estimate of value made for one context to another. A more sophisticated approach transfers the value function. The value function describes the relationship between value and key environmental and population factors influencing it. The relationship (namely the coefficients in a value function) is transferred. Meta-analysis can be used to estimate a composite value function based on several studies. Value estimates based on careful meta-analysis of several good-quality studies may produce narrower confidence intervals than a single study, provided the meta-analysis take sufficient account of variability in socioeconomic and biophysical factors (Schmidt, Manceur, and Seppelt 2016). Guidance for value transfer is available (e.g. eftec 2010 as formal guidance from UK Defra).

Table 4.1 shows estimates of the economic value of each public good covered in this study. In order to inform application to SFS policy design, the table covers the physical units that would be measured to enable the valuation, and the units used. The table also considers the practicality of applying the values to inform the scheme design, and specific consideration of the spatial variation in the values. Spatial variation is a key factor to inform policy design, as payment rates for actions in different locations need to be seen as fair – either being a consistent value, or having any variation based on robust, and transparently and consistently applied evidence.

There is considerable variation in the values identified for some public goods in Table 4.1. However, the columns in the table show the variables that determine these ranges. For example, several different values are identified relating to different aspects of biodiversity and scales of change or affected populations. These range from a small change in a habitat (value of £0.51 per household (eftec, 2006)) to wider wildlife and landscape benefits (e.g. £22.41 per household - Boatman and Willis, 2010). The public good (and change there in) valued in eftec (2006) is a small subset of what is valued in Boatman and Willis (2010) and hence the resulting £ value in eftec (2006) is smaller than the estimate in Boatman and Willis (2010). Therefore, despite being significantly different £ values, these estimates are not inconsistent.

Table 4.1 Values for public goods identified in SFS logic chains

Public good	Physical		Monetary			Practicality	Spatial variation in data
	Indicator	Unit	Indicator	Value (2020)	Unit		
Air Quality	PM2.5 removed by woodland	Kg/yr	Reduced health costs	The average asset value (PV 100, 2020 prices) for Wales in £15,300 per ha, ranging from £800 to £103,600 per ha.	£/ha	Good – values available in lookup form	High due to vegetation cover, pollution levels and populations exposed, but values already disaggregated by LA in a lookup tool[1].
	Emissions from agriculture	t NH_3 (Ammonia)/ yr	Increased health costs	Values depends on exposed population.	£/ha	*Moderate - UKCEH/ ERAMMP models exist, but need tailoring to SFS*	*Variation likely to be high - needs bespoke modelling to provide data*
Carbon sequestration	Carbon sequestered in each habitat type	tCO_2e/yr	Non-traded central carbon values[2] Marginal abatement cost in 2022.	£74 per tCO_2e (escalating).	£/tCO_2e/yr	Good – values widely used, but are being revised to align to the 2050 net zero carbon target.	None
Decarbonisation	Reduction of emissions from agricultural greenhouse gases (CO_2, CH_4, NO_2)						
		Average value £/tCO_2e/yr		*undiscounted*	*discounted*	*BEIS (2018) carbon prices escalate overtime, therefore average annual values have been included for a 30 year and 50 year time period, both discounted and undiscounted.*	
		2022 - 2052		*£146*	*£81*		
		2022 - 2072		*£217*	*£82*		
Flood risk mitigation	Number of properties with reduced flood risk	Count/yr	Avoided damage costs due to natural flood management (in line with multi-coloured manual methods).	Depends on probability of flooding, role of natural capital in risk reduction, damage costs per house and number of houses in a particular flood risk area	£/ property	Limited by physical modelling to quantify flood risk reduction: *bespoke models are costly to develop*	*Expected to be high. Location of assets in catchment and relative to beneficiaries*

<table>
<tr><th rowspan="2">Public good</th><th colspan="2">Physical</th><th colspan="4">Monetary</th><th rowspan="2">Spatial variation in data</th></tr>
<tr><th>Indicator</th><th>Unit</th><th>Indicator</th><th>Value (2020)</th><th>Unit</th><th>Practicality</th></tr>
<tr><td rowspan="2">Water quality</td><td>Length of waterbodies, current ecological status</td><td>Km/ status</td><td>WTP for avoided deterioration from NWEBS</td><td>The average value of avoiding a change from bad to poor is £ 16,700 per km/yr, poor to moderate is £19,100 per km/yr and moderate to good is £22,000 per km/yr (in 2020 prices). There are no values for good to high.</td><td>£/km (or £/km^2 for lakes)</td><td rowspan="2">Moderate to Good – lookup values available, although NWEBS data is approx. 15 year old.</td><td>Moderate. The key gap is that this value is only for when there is a change in the ecological status class.
Data does not cover lakes, which can have high recreational value.</td></tr>
<tr><td>Pollutant levels at treatment works</td><td>Kg of pollutant</td><td>Additional treatment costs for higher pollutant levels/ concentrations</td><td>£0.3 – 0.49 for sediment
£0.69 - £1.26 for nitrate
£26.66 - £33.34 for phosphorus
(Source: Farmscoper in ENCA)</td><td>£/ kg pollutant</td><td>Variation can be very high for some pollutants depending on size of water treatment works (OFWAT, 2006) [38].</td></tr>
<tr><td>Resilient ecosystems and species recovery</td><td>Various definitions, e.g. Maintenance or improvement (to favourable condition)</td><td>Ha of habitat</td><td>WTP for in favour-able or recovering condition</td><td>See Box 2.1</td><td>£/Ha of habitat</td><td rowspan="5">Moderate – value transfer possible (Annex 1)</td><td rowspan="5">None, values are average for the bundle of benefits habitats provide (NB so may double-count with other public goods).</td></tr>
<tr><td></td><td colspan="3">WTP for charismatic species, under the maintain funding scenario[4]</td><td>£19.21</td><td rowspan="4">Household /yr</td></tr>
<tr><td></td><td colspan="3">WTP for wildlife and landscape benefits[5]</td><td>£22.41</td></tr>
<tr><td></td><td colspan="3">WTP to protect rare familiar species from further decline[6]</td><td>£63.50</td></tr>
<tr><td></td><td colspan="3">WTP for a 1% improvement in rough grassland [7]</td><td>£0.51</td></tr>
</table>

[38] Ofwat (2006). What is the cost of reducing ammonia, nitrates and BOD in sewage treatment works effluent? Available at: https://www.ofwat.gov.uk/wp-content/uploads/2015/11/rpt_com_oxera080107.pdf

[1] see Pollution Removal by Vegetation, available at: https://shiny-apps.ceh.ac.uk/pollutionremoval/

[2] see Data tables 1 to 19: supporting the toolkit and the guidance, available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

[3] Redman, G. (2018). The John Nix Pocketbook for Farm Management 2019. 49th Edition. Melton Mowbray: Agro Business Consultants; Agriculture and Horticulture Development Board (AHDB). 2019. GB fertiliser prices - Latest market update: May 2020 Fertiliser Review. Available at: https://ahdb.org.uk/GB-fertiliser-prices

[4] Christie and Rayment (2012) An Economic Assessment of the Ecosystem Service Benefits Derived from the SSSI Biodiversity Conservation Policy in England and Wales.

[5] Boatman and Willis (2010) Estimating the Wildlife and Landscape Benefits of Environmental Stewardship.

[6] Christie (2006) Valuing the diversity of biodiversity. Ecological Economics 58 (2), 304-317, average value from Cambridge and Northumberland taken.

[7] eftec (2006) Economic Valuation of Environmental Impacts in the Severely Disadvantaged Areas.

Some of the conclusions in Table 4.1 are in italics to indicate where further work is needed on the evidence. Some conclusions are not in italics: evidence for Carbon; Air pollutant removal by trees; and Quality of waterbodies are based on evidence that is recognised in ENCA and can be reliably used to inform SFS payment rates.

Other benefits, in italics, need further work:

- The benefits of reducing emissions of air pollutants from agriculture (e.g. Ammonia) have been modelled by UKCEH (and are subject to further work within ERAMMP) and can be valued in line with existing air pollution valuation approaches. However, the evidence needs to be disaggregated to give local values for pollutant reduction, and this is expected to require further bespoke work – discussions are needed with specialists in UKCEH.

- The benefits of flood risk reduction have high spatial variation for both physical and economic reasons. Physically, reductions in flood risk as a result of land management measures depend on topography, the types and distribution of catchment land uses, and existing flood risk management structures. Economically, the value of damage depends on the numbers and types of residential and commercial properties protected from flooding and the severity and duration of flood. Detailed modelling of these factors would be needed in order to provide monetary values that could inform local payment rates within the SFS.

- There are estimates of the water treatment costs that arise in relation to different levels of water pollution, and can therefore be used to value changes in pollutant emissions from agriculture to water courses. Available evidence shows variation in costs depending on the size of the water treatment works and pollutants. Further work to disaggregate these values across Wales is possible. However, the best data to do so, and actual data on water treatment costs in Wales, is held by Dŵr Cymru/Welsh Water. Therefore it is suggested that Welsh Government work with Welsh Water to establish lookup values for water pollution changes that could arise in different areas of Wales due to the SFS.

- Data for resilient ecosystems and species recovery is the most complex to analyse. Indicators of ecosystems resilience from the CURVE report are identified for the assets and ecological functions in the logic chains. Related to this, species play a role (as part of biodiversity) in supporting other services (eftec 2019)[39]. The available evidence on biodiversity valuation is limited – there are only a few studies that consider ecosystem and species explicitly. Some relevant studies look at overall values (which are interpreted to represent a 'bundle', i.e. collection, of benefits) for range of habitats (e.g. Christie & Rayment 2012[40]), whereas others consider the role of biodiversity with specific habitats (e.g. in woodland) (see eftec 2019). Applying these values to SFS policy design involves value transfer, which each potential transfer needs careful consideration for its suitability to inform policy. Comparisons for five studies relevant to SFS are made in Annex 1.

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[39] eftec (2019) Feasibility Study for the Valuation of Forest Biodiversity. https://forestry.gov.scot/publications/736-feasibility-study-for-the-valuation-of-forest-biodiversity
[40] Christie and Rayment (2012) An Economic Assessment of the Ecosystem Service Benefits Derived from the SSSI Biodiversity Conservation Policy in England and Wales, Ecosystem Services.

5 INTERPRETATION OF VALUES

This section discusses issues relating to the interpretation of the valuation evidence identified. It looks at the nature of the evidence base, and considers synergies and overlaps across the logic chains. However, this is not a comprehensive analysis of all links between the logic chains. The main purpose of this work has been to produce individual logic chains to make clear how different social benefits from policy outcomes can be achieved and valued.

5.1.1 Evidence base

Economic valuation evidence is used to estimate the potential social value of the public goods in each logic chain. Section 4 shows that some of these public goods have monetary values that are practical to apply and help understand the spatial variation in the value of changes to public goods. For other public goods the economic valuation evidence needs more work, in particular to consider how relevant values are to be applied at different scales (e.g. all-Wales or specific catchments). Further analysis can be taken forward as more details of the SFS are established.

Available evidence shows a broad range for the value to society of the changes in some social benefits. Where the social values vary because the environmental outcomes have very different values from one location to another, this is useful policy evidence. For example, the value of air pollutant removal by trees varies by several orders of magnitude across local authorities in Wales – it may not be practical to vary payments by this extent within the scheme, but this is nevertheless very informative evidence for policy design. Where values have a broad range due to uncertainty, this is reflected in lower confidence levels for the results. For example, additional water treatment costs for higher pollutant levels/ concentrations vary considerably, due to factors such as the size of treatment works.

It should be noted that there remain practical challenges and risks with different areas of evidence informing SFS design, and this includes the social values identified in this report. Key issues include:

- Understanding of the physical changes in the environment being analysed, and how these will change social values (e.g. quantification of changes in flood risk as a result of ecosystem management). Economic valuation is usually only as accurate as the underlying physical evidence.
- The age of the evidence base, with a lack of recent economic valuation studies for many environmental changes.
- Uncertainties over the scale of environmental change, with a risk that thresholds are crossed, changing environmental outcomes more significantly than was envisaged when the evidence of impacts on social value was developed.
- Lags in realising benefits, which can be significant (over decades) and are not always well-known.
- Different types of valuation evidence (e.g. market prices, avoided costs, non-market values) available for different public goods, which can restrict precise comparisons.

The logic chains and monetary values should be used in conjunction with other evidence to inform SFS design. If this evidence is not used, decisions will still be based on value judgements, but implied ones that cannot be as readily scrutinised.

5.1.2 Logic chain overlaps

There are synergies and overlaps between the actions and benefits identified in the draft logic chains in Section 3. The logic chains help make these duplications transparent, so that the risks of sub-optimal scheme design can be avoided. The focus is on the actions and outcomes in the logic chains because they present the greatest risk of inaccuracy (through synergies or conflicts) in the interpretation of the values involved for policy making, namely:

- Duplicating justifications for policy measures, where multiple actions and costs, in different logic chains, could be justified on the basis of a single benefit.
- Duplicating costs of actions, where synergies mean that different logic chains involve the same actions and costs, meaning the multiple benefits of a single actions are under-recognised.

There is no risk of double counting at present, because the values identified are not aggregated and summed. Doing so would require further data and assumptions on the scale of relevant SFS measures, which are not yet determined. However, these overlaps and risk are reviewed here to provide inputs for future policy development and appraisal.

Extrapolating from logic chains to policy design also faces other challenges relating the interpretation of evidence on public goods, and balancing that evidence with more practical factors relating to scheme design and implementation. These factors include monitoring and evaluation of actions, and minimum payments necessary to stimulate engagement/ participation by farmers and other land managers. The necessary payments are dependent on farm business considerations, such as the nature of private benefits associated with the actions required to deliver public goods. These private benefits are identified in the logic chains, but have not been analysed in detail.

Overlaps are recorded on the following scale:

Major conflict	Conflict	None	Synergy	Major synergy
- -	-	N	+	++

The overlaps between the actions in the logic chains are analysed in Table 5.1. The columns and rows each represent the actions associated with a particular logic chain.

The extent of overlaps is considerable, the matrix identifies 47 overlaps between actions, all but 4 of them positive. Consideration of the overlaps of actions suggests two factors that are important to assess. Firstly, whether the actions taken are broadly similar (e.g. tree planting, reduction in stocking densities), and secondly whether they will be targeted to the same locations to achieve the outcomes in question (e.g. the same parts of catchments, close to population centres).

For example, tree planting for recreation and air quality benefits generally has highest value closer to centres of population, whereas tree planting for water quality of flood risk reduction benefits will target source catchments – these locations may or may not overlap. Similarly, different outcomes may be best served by different tree species or woodland management regimes. These factors will influence the practicality and cost-effectiveness and efficiency of designing measures for multiple outcomes.

Table 5.2 lists public good outcomes overlaps. This does not just identify the same type of outcome (e.g. Carbon sequestration), but the same outcome from the same ecosystem/ part of the farmed environment (e.g. the same Carbon sequestration process is involved). There are fewer overlaps between outcomes, which is unsurprising given that the logic chains are defined around distinct outcomes.

The analysis of overlaps in Tables 5.1 and 5.2 has been cross-checked against the ERAMMP Reports on the National Forest in Wales Evidence Pack (Report-32[41]) and the Sustainable Farm Scheme Evidence Pack (Report-10a: Integrated analysis). Both of these reports look at the evidence reflected in the logic chains in significantly greater detail, and consider overlaps between actions.

The National Forest in Wales Evidence Pack identifies some actions where the same positive overlaps as in Table 5.1 are identified, but where opposite effects (i.e. conflicts) are possible in specific circumstances, such as:

- The benefits of woodland creation for biodiversity depend on the woodland design and management being suitable for woodland species, and what species were present on the habitat being replaced by the woodland.
- Afforestation generally has a positive effect on water quality, but conifers can have a detrimental effect on certain soil types.

It also identified areas of significant uncertainty, such as the impacts of woodland on flood mitigation, which are heavily dependent on the woodland resource and the condition of catchments.

The National Forest in Wales Evidence Pack's integrated analysis includes a rating of the evidence on different benefits. This is dominated by 'Amber' ratings, indicating that "evidence may be limited and/or there is a dependency which needs to be considered" – reflecting a similar uncertainty to the Amber rating of confidence used in the logic chains.

The Sustainable Farm Scheme Evidence Pack integrated analysis[42] identifies management measures which will generate multiple benefits. It summarises (in Table 2.1.2) the frequency of types of management measures in its 9 evidence reviews. Interventions relating to management of trees and shrubs appear most frequently (in 4 of the 9 reviews) with measures on fertiliser, vegetation management, soil protection and peatlands/wetlands all appearing 3 times. These most frequently cited types of management are similar to the logic chain actions with the most overlaps identified in Table 5.1. Measures on benchmarking, baseline and skills also appear 3 times in the SFS Evidence pack integrated analysis, but these are cross-cutting measures that are outside the scope of the logic chains.

It should be noted that Tables 5.1 and 5.2 await peer review by UKCEH and Welsh Government experts in relevant SFS policy areas.

[41] Beauchamp, K., et al. (2020). ERAMMP Report-32: National Forest in Wales - Evidence Review. Report to Welsh Government (Contract C210/2016/2017)(UKCEH 06297) www.erammp.wales/32
[42] Emmett, B.A. et al. (2019). Report-10A: Integrated Analysis. ERAMMP Report to Welsh Government (Contract C210/2016/2017) (CEH NEC06297) www.erammp.wales/10a

Table 5.1 Logic chain actions overlaps

Logic Chain Name	Air quality	Carbon in woodland	Carbon in Saltmarsh	Carbon in Peatland	Carbon in Grassland	Decarbon-isation	Flood risk mitigation	Water quality	Resilient ecosystem/ species recovery	Biodiversity – direct value	Animal health	Soil husbandry
Air quality		++	N	N	N	+	+	++	+	+	N	N
Carbon in woodland			N	-	--	N	+	+	++	+	N	N
Carbon in Saltmarsh				N	N	N	+	N	++	+	N	N
Carbon in Peatland					N	N	++	++	++	+	N	++
Carbon in Grassland						N	+	+	+	+	+	++
Decarb							+	+	N	N	N	+
Flood risk mitigation								++	++	+	+	++
Water quality									+	+	+	++
Resilient eco-system/ sps recovery										++	+	++
Biodiversity direct											N	+
Animal health												N
Soil husbandry												

Table 5.2 Logic chain outcomes overlaps

Outcome		Relationship	Description
Air quality	Decarbonisation	+	Synergy as increasing decarbonisation will improve air quality as there are less pollutants in the air.
Flood risk mitigation	Resilient ecosystems/ species recovery	+	Synergy as actions such as increasing tree cover will improve flood risk mitigation and resilient ecosystem/ species recovery
Air quality	Biodiversity – direct value	+	
Water quality	Biodiversity – direct value	+	Improving water quality will improve habitats for water-based biodiversity, and certain types of biodiversity can in turn improve water quality.
Water quality	Resilient ecosystem/ species recovery	+	Synergy as actions such as increasing tree cover will improve water quality and resilient ecosystem/ species recovery
Resilient ecosystem/ species recovery	Biodiversity – direct value	+	Technically not, but hard to define/ separate
Resilient ecosystem/ species recovery	Soil husbandry	+	Soil biota are part of more biodiverse ecosystems

It is important to recognise here that the SFS could be the delivery mechanism for public goods that are the topic of several government policies (e.g. improving health, wellbeing). Overlaps with other policies and potential co-funding across Government departments are outside the scope of this analysis.

Key areas of overlap not considered in Table 5.1 and 5.2 relate to:

- Biodiversity: there are different logic chains for (i) the direct value of biodiversity (see Section 3.9), and (ii) the role of biodiversity in ecosystems and the resilience of outcomes (Section 3.6). The latter directly deals with overlaps between biodiversity actions and other social values.

- Other factors influencing SFS participation and measures used, such as the motivations, skills and capabilities of land managers, which can themselves be influenced by scheme design (e.g. in the choice of monitoring approaches) and other measures (e.g. training, business support).

The number of action overlaps identified for each logic chain outcome in Table 5.1 are tallied in Table 5.3. Flood mitigation, water quality and ecosystem resilience outcomes have the greatest number of positive overlaps, closely followed by soil husbandry. This is useful to inform policy design as these outcomes are likely to provide a greater range of benefits and so could provide more returns to efforts to coordinate them with other outcomes. However, the size and value of benefits should also be taken into account, along with variability. For example, water quality and flood risk mitigation outcomes are both very location and context dependent. So these outcomes require careful targeting to ensure benefits are realised.

Table 5.3 Count of logic chain action overlaps

Outcome	Relationship				Total
	++	+	-	- -	
Air quality	2	4			**6**
Carbon in woodland	2	3	1	1	**7**
Carbon in saltmarsh	1	2			**3**
Carbon in peatland	4	1	1		**6**
Carbon in grassland	1	5		1	**7**
Decarbonisation		4			**4**
Flood risk mitigation	4	7			**11**
Water quality	4	6			**10**
Resilient ecosystem/species recovery	6	4			**10**
Biodiversity – direct value	1	8			**9**
Animal health		4			**4**
Soil husbandry	5	2			**7**
Total	**32**	**48**	**2**	**2**	**84**

6 CONCLUSIONS AND RECOMMENDATIONS

The logic chains provided in Section 3 are the starting points for valuation of SFS outcomes and can help document the process of such valuation. The logic chains illustrate general links between a change in the extent and condition of the ecosystem (or natural capital) asset and changes in ecosystem services and the public and private benefits. They also link to some indicators of ecosystem resilience.

Simple confidence ratings are placed on the relationships identified in the logic chains. These show generally higher levels of confidence in the earlier steps in the logic chains, with more variability in the latter steps. However, further assessment is needed to fully establish the factors influencing variability in the individual linkages, and the level of confidence in whole logic chains.

Economic valuation evidence is used to estimate the potential societal value of the public goods in each logic chain. Section 4 shows that some of these public goods have monetary values that are practical to apply and help understand the spatial variation in the value of changes to public goods. For other public goods the economic valuation evidence needs more work to link to the available evidence and determine why the value to society of the changes in these public goods may have very different value from one location to another.

Further questions to consider in using these logic chains to inform SFS policy design include:

- There is a need for agreed logic chains that show the causality of links between land use / management measures and outcomes. Scrutiny and editing of the logic chains by policy experts inside Welsh Government and NRW is suggested as the best way to achieve this.
- Further work to establish the strengths of these relationships and reflect geographical differences to refine the evidence base requires detailed modelling – as being undertaken within the ERAMMP project. This will make a detailed assessment of the attributable changes the SFS can achieve relative to the regulatory baseline.
- The evidence base on the value of resilient ecosystems and species is particularly complex. The suitability for value transfer of a number of studies is considered in Section 4, and this should be discussed further to align with SFS policies.
- Further to valuing individual outcomes from the logic chains, to design SFS policy consideration is needed into the synergies between management practices: confirming which values are additive and that risks of double-counting are avoided.
- Are all the logic chains useful and distinct? The soil husbandry logic chain is defined by management of an asset (soil) rather than a public good outcome, and has overlaps with grassland carbon and other logic chains.
- The current focus is on environmental values, so the value of farm animal health and welfare has not been investigated. Further research could be conducted in this area.
- Further detail that could be added to the logic chains include:
  - Should timescales be covered in more detail (e.g. timing of when benefits arise, and how long they persist)?
  - Should beneficiaries be covered in more detail (i.e. describing who in society benefits)?

The logic chains should be used in conjunction with the ERAMMP evidence packs on SFS (ERAMMP Report-10) and National Forest Wales (ERAMMP Report-32). Those analyses and this report have all examined interactions and overlaps between potential policy actions. This information could be consolidated into a signposting tool, identifying overlaps and providing links to the relevant material within the ERAMMP outputs.

ANNEX 1. Biodiversity studies

Table A1 assesses the suitability of five UK biodiversity valuation studies for value transfer to assess the value of potential biodiversity outcomes from the SFS. The comparisons in Table A1 show that these studies could be an acceptable fit for some aspects of the SFS. However, they have weaknesses in relation to: the types of habitats covered (further scrutiny by SFS policy specialists is recommended of the relevance of 'The change' to SFS); the geographical cover; and/or the age of the evidence.

Table A1. Value Transfer Comparisons to Inform SFS Policy

Selection criteria	Policy site	Christie & Rayment (2012)	Christie et al. (2011)	eftec (2006)	Christie et al. (2006)	Boatman and Willis (2010)
The good itself	Condition of semi-natural ecosystems	Bundle of benefits (food/natural products, research and education, climate regulation, water regulation, sense of experience, charismatic/non charismatic species) related to the condition of priority habitats. Habitats include acid grassland; lowland calcareous grassland; neutral grassland; purple moor-grass and rush pastures; heathland; broadleaved, mixed and yew woodland; coniferous woodland; rivers and streams; canals; standing waters; bogs; fen, marsh and swamp; coastal and floodplain grazing marsh; inland rock; maritime cliffs; sand dunes and shingle; and intertidal mudflats and saltmarsh.	Bundle of benefits (wild food, non-food products, climate regulation, water regulation, sense of place (habitat benefits), increases in the population and range of threatened charismatic species (animals, amphibians, birds and butterflies), increases in the population and range of threatened non-charismatic species (trees, plants, insects, and bugs). Ecosystem services valued for the following BAP habitats habitat types: arable margins; upland hay meadow; blanket bog; upland heath; hedgerows; coastal floodplain; limestone pavement; fens; low calc grassland; lowland raised bog; low dry acid grass; wet reed beds; lowland heath; native woodland; low hay meadow; arable fields; purple moor grass; improved grassland; and upland calc grass.	Upland farming attributes in each English region with Severely Disadvantaged Areas (SDA). Attributes include heather moorland and bog, rough grassland, broadleaf and mixed woodland, field boundaries, and culture heritage.	Bundle of benefits, divided into ecological and anthropocentric concepts. Attributes: (1) familiar species of wildlife (2) rare, unfamiliar species of wildlife (3) habitat quality and (4) ecosystem processes. The habitat was broadly defined as farmland in England. The study used a choice experiment to value biodiversity attributes.	Bundle of benefits (increased wildlife, enhanced landscape, carbon sequestration and lower carbon emissions) resulting from the Environmental Stewardship (ES) Scheme in England. Wildlife and landscape impacts are valued through a Stated Preference (SP) study. The change in carbon emissions attributable to ES is valued through estimating the reduction in carbon emissions due to land-use changes and using the DECC (2009) carbon price (which is based on the cost of mitigation to meet carbon reduction targets in the UK).

Selection criteria	Policy site	Christie & Rayment (2012)	Christie et al. (2011)	eftec (2006)	Christie et al. (2006)	Boatman and Willis (2010)
The change	Maintaining or improving	Changes in ecosystem services were either a 25% increase or 50% decrease in food/other products, a 35% expansion or a 40% decline in research and education, an increase in storage or release of 100 kilo tonnes of CO_2 per year in carbon, 65,000 fewer people at a lower risk of flooding or 65,000 more people at a greater risk of flooding, a 35% increase or 40% reduction in the area of Sites of Special Scientific Interest (SSSI) habitat, and a 20% increase or a 55% decline in the population and range of threatened animals and insects. Changes in biodiversity and associated ecosystem services which results from 2 SSSI policy scenarios: (i) meeting the target of 95% of SSSIs in 'favourable' or 'unfavourable recovering' condition and (ii) all SSSI achieving 'favourable' condition.	At the UK level, the full implementation of the BAP scenario involved an increase of 14% in the availability of wild food and non-food products, an increase of 708,000 tonnes of CO2 sequestered each year, 67,000 fewer people at risk of flooding, 41.3% of habitats achieving favourable condition (compared to 37.3% in the baseline), all 273 threatened charismatic species stabilized (compared to 105 species stabilized and 168 in decline in the baseline), and all 876 non-charismatic species stabilized (compared to 337 species stabilized and 539 in decline in the baseline). The no further BAP funding scenario involved a decrease of 16% in the availability of wild food and non-food products, a decrease of 749,000 tonnes of CO2 sequestered each year, 69,000 more people at risk of flooding, 27.6% of habitats achieving favourable condition, all 273 threatened charismatic species in decline, and all 876 non-charismatic species in decline. Changes in biodiversity ecosystem services resulting from (i) a full implementation of the BAP and (ii) no further BAP funding.	Improvements in quantity of heather moorland and bog (-2% to +2%), rough grassland (-10% to +10%) broadleaf and mixed woodland (+3% to 20%), field boundaries (for every 1km 50m to 200m is restored), and improvements in quality of culture heritage.	Changes in biodiversity attributes were (1) to protect rare familiar species from further decline or protect both rare and common familiar species from further decline or do nothing and allow continued decline, (2) to slow down the rate of decline of rare unfamiliar species or stop the decline and ensure the recovery of rare unfamiliar species or do nothing and allow continued decline, (3) restore habitats or re-create habitats or do nothing and allow habitat degradation to continue, and (4) to restore ecosystem services that have a direct impact on humans or restore all ecosystem services or do nothing and allow the decline of the functioning of ecosystem processes.	Implementation of ES compared to the absence of the scheme. ES is complex and involves incentivising farmers and land managers to take a variety of actions, however the most widely adopted actions in all landscapes are as follows: Entry Level Stewardship (ELS): Hedgerow management, ditch management, buffer strips and field corners, in-field trees, overwinter stubbles, permanent pasture with low inputs; Higher Level Stewardship (HLS): Grassland options, options for woodland creation, maintenance and restoration, hedgerows of high environmental value, lowland heathland.
The monetary valuation		Values were identified through in annual tax increases -£25, £50, £100, £200, £300 and	Values were identified through in annual tax increases - £25 £50 £100	Values were identified through in annual tax	Values were identified through in annual tax increases - £10,	Values were identified through in annual tax increases -£0, £1, £5, £10, £15, £20, £25, £30,

Selection criteria	Policy site	Christie & Rayment (2012)	Christie et al. (2011)	eftec (2006)	Christie et al. (2006)	Boatman and Willis (2010)
		£450 / annum over the next 10 years.	£200 £300 £450 per annum over the next 10 years.	increases - £2. £5, £10, £17, £40 and £70.	£25, £100, £260, £520 and no increase in tax.	£35, £40, £50, £60, £80, £100, £150, £200, £500.
The location	Wales	England and Wales.	UK with more disaggregated (12 regions) estimates.	England (with regional disaggregated estimates: North West, North East, Yorkshire and Humber, West Midlands, East Midlands, South West, South East).	Cambridgeshire and Northumberland.	England.
The affected populations	Welsh (and possibly UK) Population	English and Welsh populations.	UK population.	English population	Cambridgeshire and Northumberland populations.	English population.
The number and quantity of substitutes	None for each specific habitat. Different semi-natural habitats may be considered substitutes in some respect. The same semi-natural habitats are present in other counties/ parts of the UK.					
		Similar habitats in the rest of the UK/ overseas	Similar habitats overseas		Assumes habitat maintenance and improvements is a public good and would be implemented through land manager actions incentivised by government.	
The market constructs	Assumes habitat maintenance and improvements is a public good and would be implemented through land manager actions incentivised by government.					
Study quality		These studies are now nearly a decade old, and socio-economic changes during that period increase uncertainty in use of their results.				
Suitability for Value Transfer		Potentially, suitable for priority habitats and ecosystems. Less relevant to other parts of farmed landscape. The study assumes SSSI are the same as priority habitats, but there might not be a direct overlap in habitat types.	Potentially, suitable for priority habitats and ecosystems. Less relevant to other parts of farmed landscape. The study focuses on priority habitats, examining a wide range of benefits (provisioning, regulation and cultural). Considers both maintaining and enhancing habitats.	The study focused on improvements in quantity rather than quality. English study, so would need adjustment to population and environmental characteristics in Wales.	Potentially suitable as the study identifies public WTP for biodiversity enhancements associated with agri-environmental, habitat re-creation, and development restriction policy. However, the study does not disaggregate between different habitats within 'farmland'. English study, so would need adjustment to population and environmental characteristics in Wales	Potentially suitable as the study identifies public WTP for the benefits provided by the Environmental Stewardship Scheme in England, disaggregated into the benefits provided by ELS and HLS schemes. English study, so would need adjustment to population and environmental characteristics in Wales.
Unit values		Estimates household consumer surplus values of six ecosystem	Estimates consumer surplus values for the ecosystem services delivered	eftec (2006) estimates WTP per household for	Christie (2006) estimates the mean annual consumer surplus	Boatman and Willis (2010) estimates the annual household

Selection criteria	Policy site	Christie & Rayment (2012)	Christie et al. (2011)	eftec (2006)	Christie et al. (2006)	Boatman and Willis (2010)
		services (wild food, research and education; climate regulation; water regulation; sense of experience; charismatic species; non charismatic species) delivered by conservation activities on SSSI habitats under the 'Maintain funding' scenario. Total value of all ecosystem services under the maintain scenario is £42.62 per household per year and for the increase funding is £34.74 per household per year. The willingness to pay for charismatic species, under the maintain funding scenario, is £19.21. This value can be disaggregated down to habitat level, where WTP for charismatic species on heathland is £7.66 and £1.67 for broadleaved, mixed and yew woodland. For natures gift (or wild foods), the overall WTP is £0.15. The WTP for ecosystem services is lower under the increase funding scenario. The attributes for the 'pooled' choice experiment model, except from non-charismatic species, are all statistically significant above 0.1.	by UK BAP habitats within 'own region' and in the rest of the UK. These results are disaggregated by country and ecosystem service. In Wales, within their own region, the WTP for non-charismatic species is £47 per household per year under an increased spend scenario and £74 under current spend scenario. For wild foods, the WTP is £15 for increased spend and £88 for current spend. There are no WTP for charismatic species in Wales as the results from the modelling were not statistically significant. For benefits delivered in the rest of the UK, only the water regulation benefit had statistically significant results. (Values from ENCA) UK WTP for enhancements to charismatic and non-charismatic species, and sense of place, associated with a significant improvement in habitat condition as a result of full implementation of UK Biodiversity Action Plans: • £84 / hectare lowland heathland • £75 /hectare coastal floodplain habitat • £72 /hectare native woodland habitat • £70 /hectare upland heath • £55 /hectare hedgerows • £53 /hectare blanket bog • £34 /hectare purple moorland grass • £8 /hectare improved grassland • £4 /hectare arable field margins	habitats related to farming (heather moorland and bog, rough grassland and mixed and broadleaf woodland). Across the English regions, the WTP for a 1% improvement in heather moorland and bog habitats is £0.82 per household per year, for rough grassland is £0.51 and for mixed and broadleaf woodland is £0.81.	per household for seven ecosystem services delivered under the two marginal change scenarios: increase current spend under BAP and maintain current spend under BAP. The total value of the increased spend scenario is £307 per household per year, and £403 per household per year for the current spend scenario. The WTP to protect rare familiar species from further decline is £36 in Cambridge and £91 in Northumberland. To protect both rare and common familiar species from further decline, those in Cambridge are WTP £93.49 and in Northumberland are WTP £97.71. To stop the decline and ensure the recovery of rare unfamiliar species, in Cambridge the WTP is £115 and £189.05 in Northumberland.	WTP estimates for the Environmental Stewardship Scheme in England. The WTP for wildlife and landscape benefits is £22.41 (lower bound estimate).

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