Green Finance Institute

LNAS
Land, Nature and Adapted Systems Advisory Group

Advice on Including Agriculture, Fisheries and Aquaculture in a UK Green Taxonomy

Developed by the Land, Nature and Adapted Systems Advisory Group

Part B: Technical Annex – Technical Screening Criteria

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Contents

Introduction

This technical annex provides the recommended technical screening criteria (TSC) for the economic activities developed by the Land, Nature and Adapted Systems (LNAS) Advisory Group (LNAS hereinafter). The rationale behind the criteria is included, along with guidance where relevant.

- For agriculture, LNAS has developed TSC for crop and livestock production to make a substantial contribution to climate change mitigation. LNAS recommends that agriculture criteria for biodiversity and ecosystems should be prioritised in the next phase of taxonomy development.
- For fisheries, LNAS has developed TSC for wild capture fisheries to make a substantial contribution to the protection and restoration of biodiversity and ecosystems.
- For aquaculture, LNAS has developed TSC for marine and freshwater fed-based aquaculture and non-fed aquaculture to make a substantial contribution to climate change mitigation.

The TSC and methodological report[1] are the core outputs of LNAS's work. All TSCs should be fully consulted on by Defra and HMT as part of the wider planned consultation process on the UK Green Taxonomy.

[1] GFI, LNAS (2024) Part A: Methodological report

1. Agriculture

1.1. Approach to the agriculture TSC

The agriculture substantial contribution mitigation criteria[2] are structured with a three-pronged approach:

Minimum baseline:

a. Assessment requirements for farms to evaluate and report their baseline emissions and sequestration. Plans in place that support low-carbon and environmentally sustainable agricultural practices, including the responsible use of antibiotics.
b. A set of mandatory baseline practices that should be adhered to as a minimum best practice for any farm that is seeking to be sustainable. These practices seek to avoid unintended consequences of climate change mitigation, such as harmful intensification of livestock to reduce emissions, while providing an environmentally sustainable baseline, such as healthy soil, to enact the optional measures that can substantially contribute to climate change mitigation.

2. **Quantitative outcome**: The farm manager or owner needs to quantitatively demonstrate progress towards net-zero by reducing greenhouse gas (GHG) emissions and maintaining or increasing carbon sequestration on the farm holding. No single trajectory has been defined for UK agricultural emissions reductions. Instead, an accompanying analysis paper provides an in-depth evaluation of several trajectory options to inform target-setting by His Majesty's Government (HMG).[3] Until such a target is set, the LNAS Advisory Group recommends that HMG adopts the Science-Based Targets Initiative's Forest, Land, and Agriculture (SBTi-FLAG) tool as the best available option that meets LNAS requirements for an agriculture reduction target. The accompanying analysis paper provides further analysis of the SBTi-FLAG tool and recommendations for HMG.

3. **Optional practices**: Recognising the diversity of the UK agriculture sector, LNAS developed a suite of practices for farm managers or owners to consider adopting, based on their system. These practices are designed to significantly reduce GHG emissions and increase carbon sequestration, to support achievement of the quantitative outcome. To help provide further guidance, a key has been provided to help group these suggested management practices (Figure 1).

Figure 1: Management Practice Key

[2] LNAS members considered existing guidance and standards to potentially use as a proxy for alignment to the TSC such as Red Tractor and Soil Association Organic Certification. LNAS members agreed that the focus of the TSC should be on outcomes and that using specific certifications or standards may both exclude businesses that are delivering on the environmental objectives and give the impression that these certifications necessarily imply environmental sustainability.
[3] GFI, LNAS (2024) "Supplementary paper: Options for defining reductions in agricultural emissions for the UK Green Taxonomy

1.2. Crop production TSC

Description: Crop production refers to economic activities that cultivate plants in agriculture for various produce. This includes the cultivation of grains, fruits, vegetables, and legumes to produce food or commodities. The economic activities in this category could be associated with several UK SIC codes, in particular, A11, A12 and A15.

Substantial Contribution Environmental Objective: Climate Change Mitigation

Context: Recognising the heterogeneity of UK farmland and the progression made in farm-level greenhouse gas (GHG) accounting tools, the recommended TSC for crop production take an outcome-based approach rather than prescribing a set of management practices farmers must adhere to. A farm manager or business owner who seeks UK Green Taxonomy alignment would be required to demonstrate progress towards net zero by reducing CO_2e emissions against a baseline and maintaining or increasing carbon sequestration on the farm holding, described in Table 3. No single trajectory has been defined for UK agricultural emissions reductions. Instead, an accompanying analysis paper provides an in-depth evaluation of several trajectory options to inform target-setting by HMG.[4] This TSC provides a suite of well-defined management practices in tables 4a and 4b. However, their primary purpose – to maximise usability – is to guide farmers to achieve the emissions reductions and carbon removals necessary.

[4] GFI, LNAS (2024) "Supplementary paper: Options for defining reductions in agricultural emissions for the UK Green Taxonomy

How to navigate these criteria for crop production	
1. Assessment and reporting	Table 1: A farm manager or business owner must evaluate and report their baseline emissions and sequestration at the farm level. All farms must develop and implement further plans to support responsible and sustainable agricultural practices.
2. Minimum Baseline Practices	Table 2: A farm manager or business owner must adhere to the minimum baseline management practices outlined in this table. Each point should be read alongside its corresponding point in the accompanying rationale box.
3. Substantial Contribution	Table 3: A farm manager or business owner must quantitively demonstrate an absolute reduction of CO_2e and maintain or increase carbon sequestration on the farm holding against a baseline that shows sufficient progress towards alignment with 1.5^{0}C.
4. Guidance for Substantial Contribution	These tables offer approaches for farmers as to which management practices they could adopt to achieve a substantial contribution to climate change mitigation. These are not considered mandatory for alignment. • Table 4a: Approaches for farmers: Well-evidenced management practices to reduce GHG emissions and increase carbon sequestration • Table 4b: Approaches for farmers: Emerging or innovative management practices to reduce GHG emissions and increase carbon sequestration
5. Demonstrating Compliance	Table 5: How to demonstrate compliance with the quantitative outcome.
6. Do No Significant Harm	Table 6: Farms will then need to comply with the Do No Significant Harm Criteria set out in this table.

Table 1: The following table is a set of mandatory assessment and reporting requirements for farms to evaluate and report their baseline emissions and sequestration at the farm level and implement plans to support environmentally sustainable agricultural practices. These assessments and management plan processes allow farmers to identify risks and opportunities for improvement and track the effectiveness of the mandatory minimum practices in Table 2 and recommended optional practices in Tables 4a and 4b.

Environmental Outcome	**Table 1: Crop production** **Mandatory assessment and reporting** for Climate Change Mitigation Substantial Contribution
Main emission sources and sinks are identified	Undertake a **GHG protocol-compliant GHG emissions assessment - using an IPPC (2019)[5] compliant GHG emission assessment calculator** of sources of emissions and sinks on the farm. The assessment will use the whole holding as a boundary. In recognition that the effects of some practices take more than one year to come into effect, a 3-year auditing of the GHG assessment is mandatory to demonstrate progress against the agreed trajectory. However, farmers should assess their GHG emissions annually and may voluntarily report on a yearly basis. The **GHG Protocol Agricultural Guidance** and the upcoming **GHG Protocol Land Sector and Removals Guidance**[6] details some of the most widely used tools (spreadsheets, software and protocols) for calculating GHG fluxes in agriculture.[7] Tools relevant for UK farmers, which are compliant with the IPPC 2019 methodology include: • **Farm Carbon Calculator**[8] • **Agrecalc**[9] • **Sandy**[10] A complete list of GHG Protocol-compliant tools can be downloaded directly.[11] A report comparing British farming carbon calculator tools can support appropriate tool selection.[12]
	Rationale: A GHG assessment at the farm level is required to identify the main emission sources and sinks on a farm holding. The user can then navigate to the management practice guidance to identify what opportunities exist to reduce those emissions and increase carbon

[5] IPCC (2019) Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
[6] GHG Protocol (2022) Draft GHG Protocol *Land Sector and Removals Guidance*, *final version expected to be published Q1 2025*
[7] GHG Protocol (2014) Agricultural Guidance
[8] Farm Carbon Calculator (n.d.) Farm Carbon Toolkit
[9] Agrecalc (n.d.) Independent farm carbon calculator
[10] Trinity AgTech (n.d.) How Sandy is revolutionising carbon assessment in agriculture
[11] GHG Protocol (2022) List of Land Sector Calculation Resources.
[12] ADAS on behalf of Defra (2024) Harmonisation of Carbon Accounting Tools for Agriculture

	sinks, thus where the greatest mitigation impact could be achieved. A study conducted by ADAS on behalf of the UK government compared results of British tools aiming to harmonise carbon accounting tools for agriculture, recommending that at minimum tools should align with the requirements of the latest standards and guidance such as ISOs 14064, 14067, the GHG Protocol Land Sector and Removals guidance (for SBTi FLAG) and the latest IPCC guidance (currently IPCC 2019). Whole holding: a single carbon account for their entire landholding, which would capture all positive and negative GHG emissions in one place. Looking at the whole holding can allow investment to be prioritised where it will have the greatest effect. A whole holding boundary can also be useful for benchmarking progress against similar farms and assist with net zero claims.
Nutrient inputs are optimised for crop demands	Record and implement a **nutrient management plan** to manage nutrient usage more efficiently and effectively and optimise the use of organic sources of crop nutrition. The plan should be based on soil testing, estimating crop nutrient requirements, recording of nutrient applications, considering field characteristics and soil type, estimating soil nitrogen supply, and where applicable analysis of manure nutrient content prior to application. The plan should be conducted each year and updated if there is a change to the cropping programme. Resources available to help implement a nutrient management plan include: • Defra: How to complete a nutrient management assessment[13] • PLANET nutrient management decision support tool[14] • Agriculture and Horticulture Development Board (AHDB) nutrient management guide[15] • Advice from a BASIS FACTS qualified advisor[16]
	Rationale: An estimated 69% of the UK's nitrous oxide emissions are attributed to agriculture. Soil nitrous oxide emissions come from three on-farm sources: grazing returns, storage and application of organic manures and nitrogen fertiliser.[17] By matching fertiliser applications with crop requirements, nutrient management planning can maximise the efficiency of fertiliser use and can help reduce the amount of nitrogen that is lost as nitrous oxide.
Soil conditions and risks are identified and managed	Assess soil and produce a **soil management plan** to understand the condition of the farm's soil and effectively plan how to increase the long-term health, productivity and resilience of the soil. The plan to improve soil condition should be based on soil testing, which assesses soil type, organic matter, texture, structure and biology, and the potential risks such as those from nitrogen leaching and erosion. Resources available to help assess soil and produce a soil management plan include: • Defra: How to assess soil, produce a soil management plan and test soil organic matter[18]

[13] Rural Payments Agency (2023) How to complete a nutrient management assessment and produce a review report
[14] PLANET (2013) Nutrient management decision support tool
[15] AHDB (2017) Nutrient Management Guide
[16] BASIS (n.d.) Find an Advisor
[17] Defra (2022) Agri-climate report 2022
[18] Rural Payments Agency (2023) How to assess soil, produce a soil management plan and test soil organic matter

	• AHDB: Characteristics of different soils[19] • The National Institute of Agricultural Botany (NIAB): soil health assessment guide[20] • Championing the Farmed Environment (CFE): soil health initiative guides for different farm systems[21]
	Rationale: Healthy soil is essential for underpinning a range of environmental and societal benefits, including food production, biodiversity, flood protection and carbon[22] - the UK's agricultural soils have been estimated to have a carbon sequestration potential of between 1-2 tonnes CO_2e ha^{-1} yr^{-1}.[23] Poor soil management can cause soil degradation, which reduces the ability of soil to perform these functions. Research by the Environment Agency (EA) found that in England and Wales, intensive agriculture has caused arable soils to lose about 40 to 60% of their organic carbon and over 2 million hectares of soil are at risk of erosion.[24] By assessing soil conditions and identifying risks, farm managers can develop a plan tailored to their land to optimise soil management for environmental benefits.

Table 2: The following table is a minimum set of mandatory baseline practices which LNAS members have discussed and concluded that farmers will need to adhere to, in addition to the absolute reduction of CO_2e emissions, to be considered taxonomy aligned. These practices aim to ensure that alongside emissions reduction, taxonomy-aligned crops are grown in a way that does not harm or convert high carbon stock land, soils are managed responsibly and crops are stored in a way which minimises waste. These practices can be seen as guardrails for managing risks and minimising negative trade-offs.

Environmental Outcome	**Table 2: Crop production** **Mandatory minimum baseline** for Climate Change Mitigation Substantial Contribution
Does not damage or convert land with high carbon value	**Crops are not grown on land with high carbon stock:** • Woodland, namely land spanning more than 0.5 hectares in area with trees having the potential to reach a height of at least five metres and a canopy cover of more than 20%. • Wetlands: areas of marsh, fen, peat, and or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters. • Peatlands: in the UK, national peat depth definitions are described at 40 cm in England and Wales and 50 cm in Scotland and Northern Ireland.

[19] AHDB (n.d.) Characteristics of different soils
[20] The National Institute of Agricultural Botany (NIAB) (2020) Soil health assessment guide
[21] Championing the Farmed Environment (CFE) (2021) UK Soil Health Initiative guides
[22] FAO (2015) Healthy soils fact sheet
[23] Sustainable Soils Alliance (n.d.) Economic and Policy Context
[24] Environment Agency (2019) The state of the environment: soil

	Rationale: • Woodland definition aligns with the National Forestry Inventory definition of woodland.[25] • Wetlands are defined as per Article 1.1 of the Ramsar Convention on Wetlands.[26] • Peatlands – when degraded, peatlands release large amounts of CO_2 and CH_4 into the atmosphere. While covering only 0.4% of the world's land, drained peatlands emit over 5% of global anthropogenic carbon emissions.[27] In the UK, peatlands are now a significant net source of GHG – emitting approximately 16 million tonnes of CO_2e each year (2023).[28] Preventing further damage can therefore play an important role in climate regulation within the UK and globally. Research from Roe et al. (2019)[29] estimates that reducing peatland conversion in the UK could deliver 1.15 $MtCO_2e$ yr^{-1} by 2050. Peatland definitions in the UK are taken from the UK Centre for Ecology & Hydrology.[30]
Soil erosion and carbon losses from soils are minimised	**Mitigate soil compaction and avoid water logging and compaction where land is drained** To minimise soil compaction during and after harvest: • Avoid or strongly reduce using machinery on wet soils, especially if prone to compaction, such as clay, clay loams and silty clay loams. Cover crops such as green manure and brassicas can be applied after loosening the soil with machinery to improve soil structure. • Utilise dedicated travel lanes for areas that have received excessive rainfall. • Avoid or minimise tillage, avoid tillage operations until soil conditions are drier than field capacity. • If issues arise problems must be rectified as soon as conditions allow. • Increase soil organic carbon content.
	Rationale: Damage from soil compaction can have a significant impact on water infiltration, root development, and ultimately grain yield the following season. Research shows that that 60-80% of soil compaction occurs from the first wheel passes, subsequent field operations account for a much smaller amount of compaction.[31] Tillage in wet conditions results in further compaction.[32] Remediating compacted soil can increase fertiliser and energy input requirements and thus, increase emissions related to soil management.[33] Increasing organic matter in soil can reduce the extent to which soil is compacted by increasing the soil's resistance to deformation and increasing soil elasticity.[34]

[25] National Forestry Inventory (2021) Woodland England 2020
[26] UNSECO (1994) Ramsar Convention on Wetlands of International Importance
[27] IPPC (2019) Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security and Greenhouse Gas Fluxes in Terrestrial Ecosystems.
[28] IUCN (2023) Peatland code
[29] Roe et al. (2019) Contribution of the land sector to a 1.5 °C world
[30] Centre for Ecology & Hydrology (2017) Implementation of an Emissions Inventory for UK Peatlands
[31] IOWA State University (2018) How to Minimize Soil Compaction During Harvest
[32] (ibid).
[33] Business Wales (2018). Better soil management: avoiding soil compaction
[34] (ibid).

	Avoid land use change from permanent grassland to cultivated crop production Permanent grassland is defined as land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for five years or more.
	Rationale: Grasslands are highly effective and stable carbon stores, storing 34% of terrestrial carbon globally.[35] Conversion of grasslands to agricultural production can turn these areas into net carbon sources, particularly when management practices are insufficient to retain sequestered carbon in the soil.[36] The definition of permanent grassland is taken from EU law as retained into UK law.[37]
Emissions embedded in post-harvest waste are reduced	**Post-harvest loss** • Avoid, minimise and reduce to the extent possible post-harvest loss. • To the greatest extent possible, post-harvest storage facilities should be free from rodents, have sufficient ventilation, and use computer controls for monitoring (e.g. for vegetable stores).
	Rationale: The Food and Agriculture Organisation (FAO) estimates that food loss and waste result in 4.4 GT CO_2e globally each year.[38] Food loss and waste occur all along the food value chain from primary production to the end consumer. In the UK, 51% of food waste occurs before the food reaches consumers, during production, post-harvest, storage, distribution and processing. Although it is difficult to disaggregate food loss and waste from agriculture from other parts of the production and distribution process, the Waste, Resources and Action Programme (WRAP) estimates 3.6 million tonnes of surplus and waste food from primary production per annum, representing 7.2% of all food harvested in the UK.[39] Reducing post-harvest loss can reduce direct production emissions and, if done at scale can reduce the 'Carbon Opportunity Cost' by releasing land from agriculture by improving productivity of available land.[40] Reducing farm-level waste can improve profitability for farm businesses while decreasing negative impacts on the environment.
Carbon stock in farmland trees is maintained	**Maintain and regenerate trees along field boundaries** Field boundaries include hedgerows and hedgebanks, drystone walls and ditches. Trees can be lines of trees or shrubs, where scrubby hedges have been allowed to grow unchecked and standard trees that have been specifically planted or selected to develop to maturity. Guidance for sustainable management of trees along field boundaries can be found: • Defra: Plant and manage hedgerows[41] • Defra: Maintain trees along field boundaries[42]

[35] Bai and Cotrufo (2022) Grassland soil carbon sequestration: Current understanding, challenges, and solutions
[36] NASA Harvest (2021) Conversion Of Grassland to Cropland Is Increasing Carbon Emissions
[37] HM Government (2013) Art 4 (1h) of EU 1307/2013
[38] FAO (2013) Food wastage and climate change
[39] WRAP (2019) An estimate for food waste and food surplus in primary production in the UK
[40] Eunomia Research and Consulting & Innovation for Agriculture (2021) Farm-level Interventions to Reduce Agricultural Greenhouse Gas Emissions
[41] Defra (n.d.) Plant and Manage Hedgerows
[42] Defra (n.d.) Maintain trees along field boundaries

	• Natural England: Hedge cutting[43] • Hedge Link[44]
	Rationale: Soils under hedgerows store a significant amount of carbon. A project by the University of Leeds found that soils beneath hedgerows stored on average 31% more carbon than in adjacent grass fields, with old hedgerows (planted over 37 years ago) storing 57% more.[45] Maintaining existing hedgerows is key to maintaining existing carbon stores. Hedgerows can have additional benefits such as reducing soil erosion and flood risk, providing forage and shelter for livestock and wildlife, and linking habitats allowing wildlife to move across the landscape, especially if the hedge contains mature trees.[46] Additionally, the Climate Change Committee (CCC) recommended that the length of hedgerows will need to increase by 40% in the UK to contribute to the country's net zero targets.[47] See Table 4a for suggested optional practices related to agroforestry.

Table 3: The following table outlines the proposed quantitative approach to demonstrate sufficient progress towards alignment with 1.5^{0}C. No single trajectory has been defined for UK agricultural emissions reductions. Instead, an accompanying analysis paper provides an in-depth evaluation of several trajectory options to inform target-setting by HMG.[48] Until such a target is set, LNAS recommends that HMG adopts the Science-Based Targets Initiative's Forest, Land, and Agriculture (SBTi-FLAG) tool as the best available option that meets LNAS requirements for an agricultural emissions reduction target. These requirements are alongside the minimum baseline practices set out in Table 1, and prior to the mandatory DNSH assessment in Table 6. Optional approaches to support emissions reductions and carbon sequestration are set out in Tables 4a and 4b.

Environmental Outcome	**Table 3: Crop production** Demonstrate a Substantial Contribution to Climate Change Mitigation
Substantial avoidance or reduction in GHG emissions is	**1. Percentage reduction of cradle to farm-gate GHG emissions and increases in biogenic carbon removals (gCO_2e) on the whole farm holding against a baseline year. The reduction target should:** a. Be sufficient to demonstrate progress towards 1.5°C alignment;

[43] Natural England (2007) Hedge cutting: answers to 18 common questions
[44] Hedge Link (n.d.) Resources
[45] Biffi et al. (2022) Soil carbon sequestration potential of planting hedgerows in agricultural landscapes
[46] Defra (n.d.) Plant and manage hedgerows.
[47] CCC (2020) Land Use: Policies for a Net Zero UK
[48] GFI, LNAS (2024) "Supplementary paper: Options for defining reductions in agricultural emissions for the UK Green Taxonomy

demonstrated and long-term carbon sequestration is maintained	b. Cover cradle to farm-gate emissions to include upstream emissions from fertiliser production[49] and livestock feed production;[50] c. Allow for a baseline based on historical data, if a farm has made substantial emissions reductions prior to the baseline year. d. Incentivise practices that increase on-farm biogenic carbon removal. **2. Above and below ground carbon stocks (tCha^{-1}) at the farm level to be maintained or increased progressively over a minimum 20-year period.** a. IPCC guidance[51] indicates that sampling soil carbon stocks should be done at depths of 0-30, 30-60 and 60 cm and beyond, as a 30 cm assessment does not take into account potential soil carbon sequestration deeper in the soil profile. **OR** Agriculture businesses who have set near-term and net zero targets through the Science Based Targets Initiative's Forest, Land and Agriculture (SBTi- FLAG) guidance[52] and tool.[53] can be considered aligned. FLAG targets must be verified and cover emissions and removals up to the farm gate.
	Rationale: **Quantitatively demonstrating progress in reducing CO2e emissions:** LNAS agreed that a UK farm manager or business owner seeking alignment with the UK Green Taxonomy will need to quantitatively demonstrate progress in reducing CO_2e emissions that is sufficient for Paris alignment or demonstrate that the farm operating in a way that is already Paris aligned. The scope should include cradle-to-farm-gate emissions, incorporating upstream emissions from fertiliser production and livestock feed, as well as on-farm emissions from soil management, livestock and energy use. The accompanying analysis paper provides an in-depth evaluation of several trajectory options to inform this target-setting by HMG.[54] **Carbon sequestration:** No absolute threshold is set for carbon sequestration given the variability of carbon sequestration and stocking potential. Nor is a specific % of carbon increase defined given the possibility of rewarding an underperforming farm through a relative target. Therefore, the proposal requires evidence of a positive direction of travel in terms of increasing carbon stocks, with the optional best practice guidance offering practices to increase carbon sequestration. This is based on Smith et al (2007)[55] estimates that 89% of the technical potential of emission reductions in the sector to 2030 and 2050 lies in soil carbon sequestration, i.e. in reducing net CO_2 emissions. A Roe et

[49] Inorganic (or synthetic) fertiliser production emissions are attributed to the energy requirements (CO_2) and use of natural gas in the production process along with the production of nitric acid (as a stage to producing ammonium nitrate) and the leakage of N_2O.
[50] Feed production emissions are attributed to soil management, land-use change (LUC), and fertiliser production, as well as electricity use during drying and processing.
[51] Penman et al. (2003) Good practice guidance for land use, land-use change and forestry
[52] SBTi (2022) Forest, Land and Agriculture (FLAG) Guidance
[53] SBTi (2024) FLAG Target Setting Tool
[54] GFI, LNAS (2024) "Supplementary paper: Options for defining reductions in agricultural emissions for the UK Green Taxonomy
[55] Smith et al. (2007) Greenhouse gas mitigation in agriculture

	al. (2019) review estimates that the technical potential of UK agriculture soil carbon sequestration is at 10.98 $MtCO_2e$ yr^{-1}. A 20-year period for carbon stock saturation maintenance is proposed in line with the IPCC 20-year soil carbon saturation period. **SBTi's FLAG guidance and tool:** The Science-Based Targets Initiative's Forest, Land, and Agriculture (SBTi-FLAG) tool provides a robust and scientifically validated method for setting GHG reduction targets in the land-use sector, including agriculture. The tool was developed using resources from the IPCC and is based on pathways outlined in Roe et al. (2019) [56] and Smith et al. 2016[57] offering a sector-specific approach to align agricultural activities with a 1.5°C target. The SBTi-FLAG tool covers both emissions and biogenic removals associated with land use up to the farm gate. This includes emissions from livestock feed (land-use change, feed production) and fertiliser use, as well as carbon removals through on-farm activities such as soil carbon enhancement and agroforestry. The accompanying analysis paper provides further analysis of the SBTi-FLAG tool and recommendations for HMG.[58]

Table 4a: The below farming management practices have been researched, tested, and implemented with a substantial body of scientific evidence supporting their effectiveness in reducing GHG emissions and sequestering carbon. These practices are not mandatory but are meant to act as best practice guidance for farmers that are aiming to decrease their GHG emissions and increase carbon sequestration to become taxonomy-aligned and may be seen as complementary to the mandatory requirements to substantially contribute to climate change mitigation, set out in Table 1, Table 2 and Table 3.

[56] Roe et al. (2019) Contribution of the land sector to a 1.5 °C world
[57] Smith et al. (2016) Science-Based GHG Emissions Targets for Agriculture and Forest Commodities
[58] GFI, LNAS (2024) "Supplementary paper: Options for defining reductions in agricultural emissions for the UK Green Taxonomy

Table 4a: Crop production - approaches for farmers Suggested management practices which are well evidenced to reduce GHG emissions and increase carbon sequestration	
Practice Description	**Rationale**
Keep bare soils covered with cover crops Plant and maintain a well-established multi-species cover crop over the winter months from the following plant groups, ensuring the inclusion of at least one legume: • brassicae • legumes • grass or cereals • herbs For maximum environmental benefits, full soil coverage is ideal. Resources available for applying cover crops include: • AGRII: Cover crops technical guide[59] • AHDB: Introduction to cover crops[60] • Defra guidance: Use of cover crops[61] • OSCAR Project: Cover crop and living mulchi[62]	Keeping bare soils covered with cover crops over winter can act as a canopy to protect the soil, recycle nutrients, slow nutrient run-off, and combat weeds, pests and diseases.[63][64] Cover crops can also absorb carbon and store it in the soil and decrease emissions from soil. Sequestration potential in the UK has been estimated at 1.06 t CO2e ha^{-1} y^{-1}.[65] Crops which include legumes have the benefit of nitrogen-fixation which can lead to less reliance on inorganic fertilisers and in turn reduce GHG emissions associated with the manufacture and application of inorganic fertiliser. Cover cropping has been estimated to reduce nitrogen leaching by 45%.[66] • Catch crops are a fast-growing cover crop that may be sown to 'catch' nitrogen before it washes out of bare soils, or to replace a failed crop to 'catch' the growing season. Mustard is an example of a catch/cover crop that grows quickly to cover and protect the soil surface, with a strong rooting system to aid soil structure.[67]

[59] AGRII (2022) Cover Crops Technical Guide
[60] AHDB (n.d.) An introduction to cover crops
[61] Defra (n.d.) Use cover crops or green manure
[62] OSCAR Project (2015) Cover crop and living mulch wiki
[63] Dabney et al. (2001) Using winter cover crops to improve soil and water quality
[64] Scavo et al. (2022) The role of cover crops in improving soil fertility and plant nutritional status in temperate climates. A review
[65] Eory et al. (2020) CO2 abatement *in the UK agricultural sector by 2050: Summary report submitted to support the 6th carbon budget in the UK*. SRUC.
[66] (ibid).
[67] Woolford and Jarvis (2017) Cover, Catch and Companion Crops Benefits, Challenges and Economics for UK Growers

	• The target is to maintain a crop residue covering the soil surface with a C:N ratio of between 25 and 30 to help maintain a healthy living soil that will release nutrients at a uniform rate.[68]
Incorporating legumes into arable rotations Implement crop rotation strategies that incorporate at least one legume species. A multi-species cover crop between cash crops counts for 1. This practice complements the cover crop practice. It is recommended that crop rotations should not have more than one occurrence of the following legume crops every six years: field beans, peas, green beans, vetches, broad beans and lupins, in order to avoid build-up of pests and disease (e.g. pea and bean weevil).[69] Resources available for applying crop rotations include: • Agricology: grain legumes in crop rotations[70] • Processors and Growers Research Organisation: guide to lupins[71]	Legumes have the ability to fix nitrogen from the atmosphere and therefore can avoid the use of inorganic nitrogen fertilisers.[72] By introducing legumes to crop rotations, the legume crops can provide a significant quantity of nitrogen to the following crops, which can reduce external fertiliser requirements and N_2O emissions across entire rotations.[73][74] • Legumes in crop rotations can also improve soil quality and drought resistance[75] and can provide an additional source of income for farm managers – the most popular legumes grown in the UK are spring/winter beans and spring peas[76]. • A study comparing ten crop rotations across three European climatic zones, found that the introduction of legumes into conventional cereal and oilseed rotations increased protein production and overall nutritional output whilst reducing synthetic fertiliser inputs.[77]

[68] AGRII (2022) Cover Crops Technical Guide
[69] Smith (2018) Increasing use of grain legumes in crop rotations
[70] Agricology (2018) Increasing use of grain legumes in crop rotations
[71] Processors and Growers Research Organisation (n.d.) Guide to lupins
[72] Peoples et al. (2019) The contributions of legumes to reducing the environmental risk of agricultural production
[73] Costa et al. (2021) Legume-Modified Rotations Deliver Nutrition with Lower Environmental Impact
[74] Watson et al. (2017) Grain legume production and use in European agricultural systems
[75] Peoples et al. (2019) The contributions of legumes to reducing the environmental risk of agricultural production
[76] Smith (2018) Increasing use of grain legumes in crop rotations
[77] Costa et al. (2021) Legume-Modified Rotations Deliver Nutrition with Lower Environmental Impact

Integrating herbal leys into arable rotations Plant herbal leys in fallow fields for a full year, as part of an arable rotation. Herbal leys are temporary grasslands made up of legume, herb and grass species. Resources available for integrating herbal leys into arable rotations include: • Agroecology: technical guidance[78] • AHDB: recommended list of grass and clover species[79] • Defra: How to establish and maintain herbal leys[80] • Soil Association: Herbal Leys 'How To' Guide[81]	Introducing herbal leys, including grass leys, into an arable crop rotation can increase the positive effects of rotation practices[82]. Diversification of arable cropping systems with grass leys can increase the quantity and continuity of below-ground residue returned to the soil. This in turn can support microbial activity and diversity and ensure the continuity of root-derived carbon inputs to soil - increasing soil organic matter.[83][84] Introducing legume species, such as clover, has the added benefit of nitrogen-fixation which can lead to less reliance on inorganic fertilisers and in turn reduce GHG emissions associated with the manufacture and application of inorganic fertilisers. Introducing herbal leys can provide co-benefits for biodiversity by providing food for pollinators, decreasing production costs by extending the grazing season and improving soil structure and fertility.[85]
Utilise precision fertiliser technologies Reduce the need for inorganic fertilisers in the first instance, by using ecological-based practices, such as legumes and improving the soil condition to retain nutrients.	LNAS agreed that practices which reduce the need for inorganic fertilisers should be prioritised in the first instance, noting that emissions associated with the manufacture, transportation and application of inorganic fertilisers as well as the impacts to the other Taxonomy objectives through nutrient runoff and water contamination, from the water-soluble inorganic fertiliser, which pose a substantial

[78] Agroecology (2019) Technical guidance for integrating grass leys into crop rotation
[79] AHDB (2018) Recommended Grass and Clover Lists.
[80] Defra (2023) How to establish and maintain herbal leys
[81] Soil Association (n.d.) Herbal Leys 'How To' Guide
[82] Prade et al. (2017) Including a one-year grass ley increases soil organic carbon and decreases greenhouse gas emissions from cereal-dominated rotations

[83] Fu et al. (2017) Soil carbon fractions in response to long-term crop rotations in the Loess Plateau of China
[84] Eory et al. (2020) Non-CO2 abatement in the UK agricultural sector by 2050
[85] AHDB (n.d.) The benefits of herbal leys

Where this is not possible, farm managers should utilise precision **technologies** including guidance, recording technologies and real-time monitoring and reacting technologies. Guidance on utilising precision fertiliser technologies includes: • Defra: precision application of fertiliser[86] • Defra: ELMs actions for precision farming[87]	environmental risk.[88][89] Inorganic N fertilisers accounted for 2.1% of global GHG emissions, with over a third attributed to production (39 %), field emissions for 59% and transportation accounting for the remaining 2%.[90] The manufacturing emissions associated with inorganic nitrogen fertilisers used on UK farms are estimated at 3 Mt CO_2e yr^{-1} (similar scale emissions from agricultural machinery).[91] Thus, efforts should be made to reduce reliance on inorganic fertilisers and, where continued use is required, should be applied using precision techniques: • In some cases, only 40-50% of N fertiliser that is applied to crops is taken up.[92][93] The unused N is lost either through groundwater leaching or by volatilisation, the loss of N to the atmosphere as ammonia (NH_3) gas and nitrous oxide (N_2O)[94]. • There are opportunities to improve the efficiency of chemical fertilisers by more accurate timing of application and by applying nitrogen to match specific plant needs. Measures can range from not applying fertiliser just before a rainstorm[95] to reacting technologies which turn recorded data (e.g. soil mapping) into decisions guiding the input applications. For example, Variable Rate Technology (VRT) allows specific rates to be applied to exact areas of the field based on results from soil testing.[96]
Introduce minimum or no tillage practices on the farm Where possible adopt cultivation techniques that do not include deep inversion ploughing, instead aiming to cultivate as little as	Minimum tillage cultivation techniques can reduce CO_2 emissions - through decreased use of fossil fuels in field preparation - and can enhance carbon

[86] Defra (n.d.) Use precision application of fertiliser, manure and other inputs
[87] Defra (2024) Technical annex: The combined environmental land management offer
[88] Cundy (2001) Groundwater and River Contamination from Intensive Agriculture
[89] Alengebawy et al. (2021) Heavy Metals and Pesticides Toxicity in Agricultural Soil and Plants: Ecological Risks and Human Health Implications
[90] Menegat et al. (2022) Greenhouse gas emissions from global production and use of nitrogen synthetic fertilisers in agriculture
[91] Innovation for Agriculture (2021) Farm-level Interventions to Reduce Agricultural Greenhouse Gas Emissions.
[92] Plett et al. (2020) The intersection of nitrogen nutrition and water use in plants: new paths toward improved crop productivity
[93] Govindasamy (2023) Nitrogen use efficiency—a key to enhance crop productivity under a changing climate
[94] (ibid).
[95] Mason et al. (2021) Farm-level Interventions to Reduce Agricultural Greenhouse Gas Emissions
[96] Eory et al. (2020) Non-CO2 abatement in the UK agricultural sector by 2050

possible, only to a depth of 15cm. In direct drilling, seeds are drilled straight into stubble with no prior cultivation. To reduce reliance on herbicides, farm managers should consider ecologically based weed management tactics such as diverse crop rotation and winter cover crops, non-chemical methods such as knife-rolling and precision agriculture methods. Reduced tillage practices are not suitable for all soil types. Resources available for minimising tillage practices include: • Defra: How to use min-till or no-till farming.[97] • SRUC: Minimum tillage technical note.[98]	sequestration.[99] By minimising soil disturbance and therefore improving the soil structure nitrate leaching can also be reduced by up to 20%.[100] However, there are some concerns that zero-till farming may increase indirect N_2O emissions in waterlogged or poorly aerated soils.[101] Reduced and no-tillage systems are currently reliant on non-selective herbicides, primarily glyphosate, to kill weeds.[102][103] These herbicides can adversely impact non-target species and can break down into AMPA[104] once in contact with water, hence potentially harming other Taxonomy environmental objectives – however many of the potential toxicity aspects remain relatively understudied.[105][106] Some studies have shown promise to minimise glyphosate in no-till systems which would be welcome, through utilising cover crops, non-chemical methods and precision agriculture.[107][108][109] The description of best practice no-tillage systems should remain under review in the Taxonomy, especially if alternatives to harmful herbicides are found to be a realistic and feasible alternative approach.
Residue Management Leave crop residues on the field when possible. A minimum application rate of 4t ha^{-1} yr^{-1} is proposed in line with the	Crop residues can contribute to the formation of soil organic carbon when left on the field which is important for both carbon storage and soil health and fertility.

[97] Defra (n.d.) How to use min-till or no-till farming
[98] SRUC (2003) Minimum tillage technical note
[99] Mangalassery et al. (2014) To what extent can zero tillage lead to a reduction in greenhouse gas emissions from temperate soils?
[100] Lampkin et al. (2019) Delivering on Net Zero: Scottish Agriculture.
[101] Mangalassery et al. (2014) To what extent can zero tillage lead to a reduction in greenhouse gas emissions from temperate soils?
[102] Eory et al. (2020) Non-CO2 abatement in the UK agricultural sector by 2050
[103] Beckie et al. (2020) Farming without Glyphosate?
[104] Department of Health (2022) Aminomethylphosphonic Acid (AMPA) and Drinking Water
[105] Gandhi et al. (2021) Exposure risk and environmental impacts of glyphosate: Highlights on the toxicity of herbicide co-formulants
[106] Kanissery et al. (2019) Glyphosate: Its Environmental Persistence and Impact on Crop Health and Nutrition
[107] Beckie et al. (2020) Farming without Glyphosate?
[108] Haleigh (2021) Integrated weed management with reduced herbicides in a no-till dairy rotation
[109] Colbach et al. (2022) Are No-Till Herbicide-Free Systems Possible? A Simulation Study

International Council on Clean Transportation's (ICCT) working paper on crop residue management in the EU.[110]	When left on the soil, crop residues generate several environmental benefits, preventing soil erosion, reducing evaporation from the soil surface, improving soil structure, supporting living organisms, contributing nutrients to the soil, and providing water filtration and retention capacity.[111]
Agroforestry systems Integrating trees on farms which are not woodland (namely not land spanning more than 0.5 hectares in an area). • **Silvoarable agroforestry** is the integration of trees with crops, including alley cropping and alley coppicing[112]. Tree rows spaced at a minimum of 10-14 m apart can allow enough room for cultivation operations, however, this will depend on the farm size. • **Hedgerows, shelterbelts and riparian strips** are forms of agroforestry where trees are grown between, rather than within parcels of land. Trees should be grown for optimal growth and survival, for a minimum of 10 years, and incorporate native and diverse species.	The IPPC AR6 report, at medium confidence, that agroforestry has a technical potential of 4.1 $GtCO_2e$ (0.3–9.4). While global estimates vary due to regional variations in management preferences, land availability, and growing conditions, there is a high level of confidence in the potential of agroforestry at the field scale.[115] Roe et al. (2019)[116] estimate the global technical potential for integrating trees into cropland at 0.4 $GtCO_2e\ yr^{-1}$. The CCC estimates that agroforestry, including expanding hedgerows, could deliver 6 $MtCO_2e$ of savings by 2050 in the UK and that the bulk of these CO_2e savings (4.8$MtCO_2e$) will be achieved by converting 10% of arable land to silvoarable systems.[117] Agroforestry also offers numerous co-benefits. In the UK, silvoarable agroforestry can provide shade for crops, enhance nutrient cycling, improve air quality by capturing pollutants, offer habitat for pollinators and wildlife, reduce soil erosion and enhance water retention.[118][119] Silvoarable systems require fewer nitrogen

[110] International Council on Clean Transportation (2017) Review of the impact of crop residue management on soil organic carbon in Europe
[111] (ibid).
[112] Soil Association (2019) The Agroforestry Handbook
[115] IPCC (2022) 6th Assessment Report
[116] Roe et al. (2019) Contribution of the land sector to a 1.5 °C world
[117] CCC (2020) Sixth Carbon Budget report
[118] Mercer et al. (1996) Valuing Soil Conservation Benefits of Agroforestry Practices
[119] CEH and Rothamsted Research (2018) Quantifying the impact of future land use scenarios

For maximum environmental benefits trees should be grown for a minimum of 30 years.[113] For further guidance refer to Defra's agroforestry ELMs actions.[114]	inputs, both because they reduce the crop area and because greater litter input and extensive root systems fix nitrogen in the soil.[120] Alley crops also provide dedicated traffic lanes for on-farm machinery, thus mitigating risks from soil compaction.[121] Depending on the specific crops used, silvoarable agroforestry can also increase total yields and profitability, offering additional income streams for farm managers, such as from fruit or nut trees and sustainable timber production.[122]
Increase carbon storage in low productivity and degraded land: Conversion of low productive arable land into woodland Convert low-grade, unprofitable arable land into woodland and take the land out of arable crop production. • Woodland is land spanning more than 0.5 hectares in area with trees having the potential to reach a height of at least five metres and a canopy cover of more than 20%.[123] **Restoration of peatlands in lowland cropland** Restoration of peats on lowland cropland includes full restoration to a near-natural state and taking the land out of production **OR** restoration of the water table and usage of the land for paludiculture crops.	**Woodland conversion** Converting low productivity or marginal land into woodland can significantly increase a farm's carbon sequestration capacity whilst generating co-benefits for the wider farming system.[126] Well-designed woodland can have a beneficial impact on food production by improving soil health, managing water resources and improving biodiversity. Woodland can also make a farming business more resilient by providing an additional income stream from timber, carbon units or other forest-based commodities such as fruits and nuts.[127] In areas which are unsuitable for woodland creation, scrubland, multi-species meadows or other habitats can increase sequestration potential while providing habitats for wildlife. **Peatland restoration**

[113] Burgess et al (2022) The Potential Contribution of Agroforestry to Net Zero Objectives
[114] Defra (2024) Technical annex: The combined environmental land management offer
[120] (ibid).
[121] IOWA State University (2018) How to Minimize Soil Compaction During Harvest
[122] CEH and Rothamsted Research (2018) Quantifying the impact of future land use scenarios
[123] National Forestry Inventory (2021) Woodland England 2020
[126] The Forestry Commission (2023) The benefits of woodland creation.
[127] The Forestry Commission (2021) It's time to branch out: How woodland creation benefits your farm

• Peat restoration of lowland peat soils involves rewetting the peat by restoring and maintaining water levels to significantly slow the rate at which peat is being lost. The UK's Lowland Agricultural Peat Task Force recommends that the optimal water level depth is when the soil water content is somewhere between saturation and field capacity.[124] • Guidance for rewetting raising water levels on grassland on peat soils includes Defra's countryside stewardship grant.[125] • See Table 4b for paludiculture. 	In the UK, peatlands are now a significant net source of GHG, emitting 23.1 $MtCO_2e\ yr^{-1}$.[128] While arable cropland occupies just 7% of the peat area, it contributes significantly to these emissions, accounting for 32% of the total GHG emissions from UK peat. Arable cropland on peat has the highest GHG emissions per unit of land due to drainage[129] — 90% of lowland peat area has been drained for agriculture — which causes plant material to decompose leading to high CO_2 emissions and fertilisation leading to high N_2O emissions.[130] Healthy peats store vast amounts of carbon - the CCC's net zero balanced pathway recommended that 25% of lowland cropland should be restored to near natural condition and that 15% be under paludiculture farming by 2050 to reach UK net zero.[131] • Restoration involves rewetting the lowland cropland, field evidence in the UK indicates that for every 10cm reduction in water-table depth, until a depth of 30cm below ground surface has been reached, 3 tonnes of CO2 per hectare would be saved each year.[132][133] Water-table depths should not be raised above the saturation point that creates conditions that release methane emissions.[134]

Table 4b: The below set of farming management practices are emerging and less established, with less scientific validation or a shorter track record of successful adoption. While promising, they may require further research, testing, piloting, investment, and regulatory revision to be widely accepted. These practices are not mandatory but are meant to act as guidance for farmers who are aiming to decrease their GHG emissions and increase carbon

[124] Lowland Agricultural Peat Task Force (2023) Chair's Report
[125] Rural Payments Agency and Natural England (2022) SW18: Raised water levels on grassland on peat soils
[128] Evans et al. (2017) Implementation of an emission inventory for UK peatlands
[129] Drainage also means large areas of lowland peat, notably in the East Anglian Fens which are used for growing fruit and vegetables, are now below sea level and at risk from flooding.
[130] (ibid).
[131] CCC (2021) Sixth Carbon Budget Report
[132] UKCEH (2020) Paludiculture report for Defra
[133] Lowland Agricultural Peat Task Force (2023) Chair's Report
[134] (ibid).

sequestration to become taxonomy-aligned. They may be seen as complementary to the mandatory requirements to substantially contribute to climate change mitigation, set out in Table 1, Table 2 and Table 3.

Table 4b: Crop production - approaches for farmers Suggested management practices which are emerging to reduce GHG emissions and increase carbon sequestration	
Practice Description	**Rationale**
Deploy seeds and management practices for high Nitrogen Use Efficiency (NUE) • Use of seeds which have been developed through genomic analysis and selective breeding to demonstrate a high nitrogen use efficiency. • In the UK, refer to Defra's Crop Genetic Improvement Platform for NUE projects.[135] 	NUE can be improved both by adopting improved crop, soil and fertiliser management practices and through plant breeding for high NUE. Scotland's Rural College (SRUC) found that improved crop varieties (based on higher NUE) could result in a cumulative nitrogen reduction in wheat, barley and oilseed rape of 13% across the UK, with a 10% increase in seed price.[136] Decreasing application rates of synthetic N fertiliser can decrease N_2O emissions while also reducing nutrient runoff into the wider environment.
Apply nitrification/urease inhibitors to soils Inhibitors and stabilisers are chemical additives that stop or slow biological nitrogen processes in the soil. The inhibitors can be applied alongside the fertilisers through injection into the soil (for liquid fertilisers), as a coating on granular fertilisers or can be mixed into slurry for application.	There are two types of inhibitors broadly used: • Nitrification inhibitors decrease the activity of nitrifying bacteria and thus reduce the conversion of ammonium to nitrate, which subsequently becomes denitrified to form N_2O. • Urease inhibitors (used with urea fertilisers) delay the conversion of urea to ammonium carbonate which is subsequently converted to N_2O.[137]

[135] Defra (2018) Crop Genetic Improvement Platform
[136] SRUC (2020) Non-CO2 abatement in the UK agricultural sector by 2050
[137] Eory et al. (2020) Non-CO2 abatement in the UK agricultural sector by 2050

	The soil N_2O emission factor has been shown to be reduced by 25% for nitrification inhibitors and 50% for combining nitrification inhibitors with urea inhibitors.[138] While nitrification inhibitors are currently available on the market, further research and evidence is needed on impacts and application rates.
Soil amendments **Biochar application:** • Source biomass for biochar production from sustainable feedstocks such as available agriculture and crop residues and other waste materials, such as manure, only. These must comply with environmental regulations. ○ The European Biochar Certificate (EBC) guidelines for the sustainable production of biochar list possible feedstocks from residues and waste materials[139] • Life cycle analysis (LCA) from source to application should be performed to ensure that sequestration benefits are not negated from the energy requirements for the pyrolysis or gasification process. • Recommended application rates vary depending on biochar properties and soil type, however, recommended rates often range between 10 and 50 tonnes per hectare.[140][141][142]	**Biochar** Biochar is produced from organic matter (biomass) using the pyrolysis process, making it resistant to decomposition, this can stabilise organic matter added to soil and provide a potential long-term store of carbon. The IPCC (2022) estimates the global mitigation potential of biochar at 0.03–6.6 $GtCO_2e\ yr^{-1}$ by 2050 based on studies with widely varying assumptions, definitions of potential, and scope of mitigation processes.[144] The IPPC reports that the greatest uncertainty for biochar is the availability of sustainably sourced biomass for biochar production.[145] Griscom et al. research[146] estimates that the global carbon sequestration potential of biochar will be 1.1 $GtCO_2$ by 2050, where sources are limited to available crop residue only and biochar is applied to all global croplands. LNAS agreed that purpose-grown biomass should not be considered as a taxonomy aligned feedstock but to use only available crop and forestry residues, and wood, animal and biodegradable municipal waste.

[138] (ibid).
[139] European Biochar Certificate (2023) Guidelines for a sustainable production of biochar
[140] Li et al. (2023) Biochar for Soil Carbon Sequestration: Current Knowledge, Mechanisms, and Future Perspectives
[141] Vijay et al. (2021) Review of Large-Scale Biochar Field-Trials for Soil Amendment and the Observed Influences on Crop Yield Variations
[142] Brown et al. (2023) Biochar application to temperate grasslands: challenges and opportunities for delivering multiple ecosystem services
[144] IPCC (2022) Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change
[145] (ibid).
[146] Griscom et al. (2017) Natural climate solutions

• In the UK, land managers can only spread up to 1 tonne per hectare without the need for an environmental permit and must adhere to certain feedstock and storage conditions.[143]	To be considered truly carbon-negative, a biochar system must also consider production emissions from the pyrolysis process and transportation, via an LCA, to ensure application to soil deliver true carbon removals.[147][148] Research has shown that biochar can also enhance soil fertility, water retention, and nutrient availability, benefiting crop productivity and overall ecosystem health.[149] Biochar's physicochemical properties depend on source material, pyrolysis temperature, local climate and soil type which can create uncertainty and variation for optimal application rates, stability and persistence of carbon within biochar-amended soils and environmental co-benefits.[150][151]
Incorporate low carbon machinery, heating and cooling into farm systems If on-farm emissions from machinery make a significant contribution to the farm's overall emissions, switching to low carbon farm machinery and low carbon heating and cooling are options farms may consider. Low carbon machinery will likely be electric, with hydrogen-powered machinery potentially being developed in the future. Farms can also replace fossil fuel use for heating and cooling with low-carbon and renewable alternatives. This would primarily mean replacing boilers with heat pumps, which require electricity. Heat pumps redirect waste heat from other processes (e.g., nearby	Agriculture accounts for 1.7% of CO_2 emissions in the UK, however, the CCC has estimated that energy use from static and mobile machinery on farms has increased by 14% since 2008.[155] Although most agricultural emissions are N_2O and CH_4 from crop and livestock management, some farming businesses may have significant CO_2 emissions from machinery, heating and cooling. Using low carbon fuels such as electric or biomethane or using low carbon heating and cooling means burning less fossil fuel, therefore reducing GHG emissions.[156] In its Balanced Net Zero Pathway, the CCC acknowledges low take-up of low carbon machinery but assumes biofuels and electrification options are taken up

[143] Environment Agency (2024) Storing and spreading biochar to benefit land
[147] Li et al. (2023) Review of biochar production via crop residue pyrolysis: Development and perspectives
[148] Carva et al. (2022) Life Cycle Assessment (LCA) of Biochar Production from a Circular Economy Perspective
[149] IPCC (2022) 6th Assessment Report
[150] Li et al. (2023) Biochar for Soil Carbon Sequestration: Current Knowledge, Mechanisms, and Future Perspectives
[151] Nair et al (2022) The use of biochar for reducing carbon footprints in land-use systems: prospects and problems
[155] Baker et al. (2022) Decarbonisation of mobile agricultural machinery in Scotland – an evidence review
[156] Innovation for Agriculture (2021) Reducing Greenhouse Gas Emissions at Farm Level

wastewater treatment plants) and can also work well with on-site or nearby anaerobic digesters. **Explore on-farm energy production through agrivoltaics** Agrivoltaics refers to the integration of solar panels into an agricultural system.[152] Solar panels are installed elevated above crops, so the system produces energy alongside the crops. Crops which have promising potential for agrivoltaics systems include leafy greens, fodder crops such as clover grass and several types of fruits, berries and herbs.[153] Farmers can refer to SolarPower Europe's best practice guidance for case studies and guidelines for implementation.[154]	widely from the mid-2020s and hydrogen fuel cells for larger applications from 2030 for mobile machinery.[157] **Note:** If electricity to power new machinery comes from the grid, the emissions reduction potential will depend on the fuel mix used to produce electricity.[158] **Explore on-farm energy production through agrivoltaics** Agrivoltaic systems can contribute to climate change mitigation by producing renewable energy without displacing agriculture. Agrivoltaic systems typically supply the host farm with energy and sell the excess back to the grid (this opportunity is dependent on accessibility to the grid which can be challenging in some rural contexts). Incorporating agrivoltaics into farming systems can help improve business resilience of farms by diversifying income streams. Additionally, energy produced on farms can decrease energy costs for farmers, protecting them against volatility in the global energy market. Solar panels can protect shade-tolerant crops from the sun and high temperatures as well as decrease evapotranspiration, helping to keep soils moist even in drought.[159] This can also decrease the need for irrigation and improve on-farm water use efficiency. More research is needed to determine the impact of agrivoltaics on different crop types, however, under certain conditions, leafy greens, fodder crops such as clover grass, several types of fruits and berries and herbs and spices have seen increased yields in agrivoltaic systems.[160]
Restoration of peatlands in lowland cropland	**Peatland restoration and paludiculture** Healthy peats store vast amounts of carbon - the CCC's net zero balanced pathway recommended that 25% of lowland cropland should be restored to

[152] Trommsdorff et al. (2024) Agrivoltaics: Opportunities for Agriculture and the Energy Transition
[153] Trommsdorff et al. (2022) Chapter 5: Agrivoltaics: solar power generation and food production in Gorjian & Campana (eds). Solar Energy Advancements in Agriculture and Food Production Systems
[154] SolarPower Europe (2023) Agrisolar Best Practice Guidelines.
[157] CCC (2020) The sixth carbon budget methodological report.
[158] Eunomia and Innovation for Agriculture (2021) Farm-level Interventions to Reduce Agricultural Greenhouse Gas Emissions
[159] Adeh et al. (2018) Remarkable agrivoltaic influence on soil moisture, micrometeorology and water-use efficiency
[160] Trommsdorff et al. (2022) Chapter 5: Agrivoltaics: solar power generation and food production in Gorjian & Campana (eds). Solar Energy Advancements in Agriculture and Food Production Systems

Restoration of peats on lowland cropland includes full restoration to a near-natural state and taking the land out of production OR restoration of the water table and usage of the land for paludiculture crops. • See Table 4a for peatland restoration • Paludiculture involves rewetting lowland peat and keeping the land in production. This is through growing specific crops suitable for high-water table conditions and ideally, those that contribute to further peat formation. Crops which have promising potential for paludiculture in the UK include salad crops such as celery and botanicals such as juniper.[161] However, further paludiculture crop research is needed.	near natural condition and that 15% be under paludiculture farming by 2050 to reach UK net zero.[162] Paludiculture is a potential agriculture system to grow crops on rewetted peat, see Table 4a for further information. However, in 2021 the UK Centre for Ecology and Hydrology (UKCEH) reported that paludiculture does not yet offer a large-scale or immediately implementable solution to the challenge of high GHG emissions from cultivated lowland peats. They emphasised that further research and development into the potential of high-water table crops is needed.[163]

[161] Abel et al. (2013) The Database of Potential Paludiculture Plants (DPPP) and results
[162] CCC (2021) Sixth Carbon Budget report
[163] UKCEH (2022) An Assessment of the Potential for Paludiculture in England and Wales. Managing agricultural systems on lowland peat for decreased greenhouse gas emissions

Table 5: How to demonstrate compliance

To demonstrate compliance it will be necessary to:
• Deploy all minimum baseline management practices, including a **GHG protocol compliant GHG emissions assessment.**
• The carbon stock and GHG emission baseline should include:
    ○ CO_2 emissions and removals in below and above ground biomass and soils
    ○ CO_2, N_2O and NH_3 emissions from exposed soils, fertiliser application, and those embedded in fertiliser production and fertiliser application
    ○ CH_4 emissions from livestock (enteric fermentation and manure management) and some soils (e.g. wetlands)
    ○ CO_2 emissions from energy use
    ○ Develop a **carbon management plan** to set out the management practices that will deliver the GHG emissions reduction / increased carbon sequestration
• Track and verify progress against the agreed trajectory through a carbon audit every 3 years.

Table 6: Do No Significant Harm is the second of the tests that an activity must show it meets in order to be deemed taxonomy-aligned. The below Do No Significant Harm (DNSH) criteria will set out how crop production does not significantly harm any of the other five environmental objectives while making a substantial contribution to climate change and mitigation. Crop production can have significant environmental impacts outside of climate change that need to be considered for investments in the sector. Based on that understanding, LNAS suggests the DNSH criteria could include the below list of potential impacts against the other five environmental objectives:

- **Climate change adaptation:** The ability of farming systems to adapt to climate change
- **Sustainable use and protection of water and marine resources:** Impact on water quantity, water quality and water ecosystems
- **Transition to a circular economy:** Pollutant and nutrient runoff and leaching
- **Pollution prevention and control:** Impacts on air quality
- **Protection and restoration of biodiversity and ecosystems:** Impact on habitats and species

It should be noted that the Green Technical Advisory Group (GTAG) set out a series of recommendations to the UK government on how to approach the development of DNSH criteria in the UK Green Taxonomy, in its August 2023 paper on this topic.[164] There have been usability issues observed in DNSH criteria in other jurisdictions to date, which include issues due to the drafting of the criteria themselves, and GTAG provided advice on potential ways to fix these issues. Therefore LNAS recommends that the DNSH criteria for crop production be fully developed once the UK government has clarified its approach to DNSH in the UK Green Taxonomy. As such, this table sets out guidance as to what LNAS considers the primary issues that the final DNSH criteria for crop production should address, but LNAS has not proposed the final wording for the criteria at this stage, pending the UK government's clarification of its way forward on DNSH.

Table 6: Do No Significant Harm (DNSH) criteria	
Climate Change Adaptation	• LNAS recommends that the UK government develop the DNSH criteria for climate change adaptation once the UK government has clarified its approach to adaptation and DNSH in the UK Green Taxonomy.
Sustainable use and protection of water	• Activities should minimise raw material use per unit of output, including energy through increased resource use efficiency • Identify and manage risks related to water quality and/or water consumption and develop a water management plan to minimise risks • Activities should use residues and by-products in the production or harvesting of crops where possible to reduce demand for primary resources • If applying inorganic or fertilisers, activities should use precision techniques, which if used correctly can minimise excess and nutrient run-off.
Transition to a circular economy	• Activities should minimise the loss of nutrients (in particular nitrogen and phosphate) leaching out from the production system into the environment. This should be delivered through the minimum baseline practice for nutrient management set out in Table 1 and through the suggested precision fertiliser practice set out in Table 2.
Pollution prevention and control	• Activities ensure that nutrients and plant protection products are targeted in their application to reduce the risk of leaching into the environment. This should be delivered through the minimum baseline practice for nutrient management set out in Table 1.

[164] GFI, GTAG (2023) Streamlining and increasing the usability of the Do No Significant Harm (DNSH) criteria within the UK Green Taxonomy

Protection of Healthy Biodiversity and Ecosystems	• Activities do not lead to conversion, fragmentation or unsustainable intensification of high nature-value land.
	• Activities should not:[165]
	   ○ result in a decrease in the diversity or abundance of species and habitats of conservation importance or concern;
	   ○ contravene existing management plans or conservation objectives;
	   ○ lead to overgrazing and other forms of degradation of grasslands.
	• Where activities involve the production of novel non-native or invasive alien species, their cultivation should be subject to an initial risk assessment and ongoing monitoring in order to ensure that sufficient safeguards are in place to prevent escape to the environment

1.3. Livestock production TSC

Environmental Objective: Climate Change Mitigation

Description: Livestock production refers to economic activities that raise animals in agriculture for various products. This includes cattle, sheep, goats, pigs, and chickens, which serve as sources of milk, meat, wool, and eggs. The economic activities in this category could be associated with several UK Standard Industrial Classification (SIC) codes, in particular A14 and A15.

Context: Recognising the heterogeneity of UK farmland and the progression made in farm-level greenhouse gas (GHG) accounting tools, the TSC for livestock production takes an outcome-based approach rather than prescribing a set of management practices that farmers must adhere to. A farm manager or business owner who seeks UK Green Taxonomy alignment would be required to demonstrate progress towards net zero by reducing CO_2e emissions against a baseline and maintaining or increasing carbon sequestration on the farm holding, as described in Table 3. No single trajectory has been defined for UK agricultural emissions reductions. Instead, an accompanying analysis paper provides an in-depth evaluation of several trajectory options to inform future target-setting by HMG.[166] This TSC provides a suite of well-defined management practices in tables 4a and 4b. However, their primary purpose is to maximise usability and guide farmers to achieve the emissions reductions and carbon removals necessary.

[165] Retained from the EU's TEG (2020) recommended TSC for livestock production and consistent with HM Government (1992) Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna

[166] GFI, LNAS (2024) "Supplementary paper: Options for defining reductions in agricultural emissions for the UK Green Taxonomy

How to navigate these criteria for livestock production	
1. Assessment and reporting	Table 1: A farm manager or business owner must **evaluate and report their baseline emissions and sequestration at the** farm level. All farms must develop and implement further plans to support responsible and sustainable agricultural practices.
2. Minimum Baseline Practices	Table 2: All farms must adhere to the **minimum baseline management practices** outlined in this table. Each point should be read alongside its corresponding point in the accompanying rationale box.
3. Substantial Contribution	Table 3: A farm manager or business owner must adhere to the minimum baseline management practices outlined in this table. Each point should be read alongside its corresponding point in the accompanying rationale box.
4. Guidance for Substantial Contribution	These tables offer approaches for farmers as to which management practices they **could** adopt to achieve a substantial contribution to climate change mitigation. **These are not considered mandatory for alignment.** • Table 4a: Approaches for farmers: Well-evidenced management practices to reduce GHG emissions and increase carbon sequestration. • Table 4b: Approaches for farmers: Emerging or innovative management practices to reduce GHG emissions and increase carbon sequestration.
5. Demonstrating Compliance	Table 5: How to demonstrate compliance with the quantitative outcome.
6. Do No Significant Harm	Table 6: Farms will then need to comply with the Do No Significant Harm criteria set out in this table.

Table 1: The following table is a set of mandatory assessment and reporting requirements for farms to evaluate and report their baseline emissions and sequestration at the farm level and implement plans to support environmentally sustainable agricultural practices. These assessments and management plan processes allow farmers to identify risks and opportunities for improvement. They also allow them to track the effectiveness of the mandatory minimum practices set out in Table 2 and the recommended optional practices set out in Tables 4a and 4b.

Environmental Outcome	**Table 1: Livestock production** **Mandatory assessment and reporting** for climate change mitigation Substantial Contribution
Main emission sources and sinks are identified	Undertake a **GHG protocol compliant GHG emissions assessment - using an IPPC (2019)**[167] **compliant GHG emission assessment calculator** of sources of emissions and sinks on the farm. The assessment will use the **whole holding** as a boundary. In recognition that the effects of some practices take more than one year to come into effect, a 3-year auditing of the GHG assessment is mandatory to demonstrate progress against the agreed trajectory. However, farmers should assess their GHG emissions annually and may voluntarily report on a yearly basis. The **GHG Protocol Agricultural Guidance** and the upcoming **GHG Protocol Land Sector and Removals Guidance**[168] details some of the most widely used tools (spreadsheets, software and protocols) for calculating GHG fluxes in agriculture.[169] Tools relevant for UK farmers, which are compliant with the IPPC 2019 methodology include: • **Farm Carbon Calculator**[170] • **Agrecalc**[171] • **Sandy**[172] A complete list of GHG Protocol-compliant tools can be downloaded directly.[173] A report comparing British farming carbon calculator tools can support appropriate tool selection.[174]

[167] IPCC (2019) Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
[168] GHG Protocol (2022) Draft GHG Protocol *Land Sector and Removals Guidance*, *final version expected to be published Q1 2025*
[169] GHG Protocol (2014) Agricultural Guidance
[170] Farm Carbon Calculator (n.d.) Farm Carbon Toolkit
[171] Trinity AgTech (n.d.) How Sandy is revolutionising carbon assessment in agriculture
[172] (ibid).
[173] GHG Protocol (2022) List of Land Sector Calculation Resources.
[174] ADAS on behalf of Defra (2024) Harmonisation of Carbon Accounting Tools for Agriculture

	Rationale: A GHG assessment at the farm level is required to identify the main emission sources and sinks on a farm holding. The user can then navigate to the management practice guidance to identify what opportunities exist to reduce those emissions and thus where the greatest mitigation impact could be achieved. A study conducted by ADAS on behalf of the UK government compared results of British tools aiming to harmonise carbon accounting tools for agriculture, recommending that at minimum tools should align with the requirements of the latest standards and guidance such as ISOs 14064, 14067, the GHG Protocol Land Sector and Removals guidance (for SBTi FLAG) and the latest IPCC guidance (currently IPCC 2019). Whole holding: a single carbon account for their entire landholding, which would capture all positive and negative GHG emissions in one place. Looking at the whole holding can allow investment to be prioritised where it will have the greatest effect. A whole holding boundary can also be useful for benchmarking progress against similar farms and assist with net zero claims.
Improved animal health and welfare and reduced antimicrobial resistance	Develop and implement a **health management plan**, that improves hygiene and supervision at parturition, improves maternal nutrition in late gestation to increase offspring survival and improves fertility management. The health management plan should include planned vaccination programmes tailored to each species. Resources available for improved animal health and welfare include: • Department for Environment, Food and Rural Affairs (Defra): Animal health and welfare standard[175] • Innovation for Agriculture (IfA): responsible use of medicines and improved animal welfare platform[176]
	Rationale: Improving livestock health contributes to a productive herd/flock and means animals are using feed resources efficiently.[177] This can be achieved by active health planning, prevention of diseases, effective biosecurity, improved housing conditions, and improved disease screening and monitoring.[178]
	Responsible use of antibiotics Develop and implement a responsible use of antibiotics and medicines plan to reduce animal health risks. The plan should ensure that there are: 1. No routine (growth promotion and prophylactic) use of antibiotics (both shared-class and animal-only antibiotics) in alignment with the 2019/6 EU regulation.[179]

[175] Defra (2023) Sustainable Farming Incentive (SFI) Animal Health and Welfare Pathway
[176] Innovation for Agriculture (IfA) (n.d.) facilitates the responsible use of medicines and improved animal welfare in British farms
[177] WWF-UK (2021) Reducing Greenhouse Gas Emissions at Farm Level
[178] (ibid).
[179] EU (2019) Regulation (EU) 2019/6 on veterinary medicinal products and repealing Directive 2001/82/EC

	2. No use of Highest Priority Critically Important Antibiotics while Critically Important Antibiotics should only be used for therapeutic purposes after susceptibility testing proves other classes of antibiotics are ineffective. Treatment should be administered to the individual animal only in alignment with WHO guidelines.[180] A list of critically important and highest priority critically important antimicrobials is set out in Annex A. 3. Avoid metaphylactic use of antimicrobials – to be used only when there is substantial and demonstrable risk of infection spreading and where suitable alternatives are not available.
	Rationale: LNAS members firmly agreed that the overuse of antimicrobials in food-producing animals poses significant environmental and public health risks, in particular the increased risk of antimicrobial resistance (AMR).[181] Misuse and overuse of antimicrobials can be used to compensate for poor animal welfare practices and allow for unsustainable intensification of livestock systems. Tackling the misuse and overuse of antimicrobials in animals is part of the UK 5-year action plan for antimicrobial resistance 2019 to 2024, with new targets for food-producing animals in development.[182] Investors are also increasingly concerned about the systemic risks to portfolios posed by AMR.[183] WHO launched guidelines in 2017 on the use of medically important antimicrobials in food-producing animals, recommending that farmers and the food industry stop using antibiotics routinely to promote growth and prevent disease in healthy animals. In 2022, the EU banned the routine use of antimicrobials in food-producing animals and restricted the preventative (prophylactic) use and control (metaphylactic) use. The EU's legislation on the use of antimicrobials in animals will apply to any animal products exported from the UK to the EU. In an addendum to the UK's 5-year action plan for antimicrobial resistance 2019 to 2024, the UK government committed to implementing similar provisions in the UK.

Table 2: The following is a minimum set of mandatory baseline practices that LNAS members have concluded that farmers will need to adhere to, in addition to the emissions reduction threshold, in order to be considered taxonomy-aligned. These practices aim to ensure that, alongside emissions reduction, taxonomy-aligned livestock is produced with high animal health and welfare. They also aim to ensure that emissions are not reduced through harmful intensification of livestock, resulting in diminished animal welfare and harmful environmental impacts. Finally, the baseline practices also aim to ensure that imported feedstocks do not contribute to deforestation and other harmful land use change and that farm soils are managed responsibly.

[180] World Health Organisation (2017) Guidelines on the use of medically important antimicrobials in food-producing animals
[181] World Health Organisation (2017) Guidelines on the use of medically important antimicrobials in food-producing animals
[182] HM Government (2019) Tackling antimicrobial resistance 2019–2024: The UK's five-year action plan
[183] Investor Action on Antimicrobial Resistance (2022) Progress Report: Investor efforts, achievements and opportunities ahead

Environmental Outcome	**Table 2: Livestock Production** **Mandatory minimum baseline** for Climate Change Mitigation Substantial Contribution
Does not damage or convert land with high carbon value	**Land with high carbon stock is not converted for livestock production:** • Woodland, namely land spanning more than 0.5 hectares in area with trees having the potential to reach a height of at least five metres and a canopy cover of more than 20%. • Peatlands: in the UK, national peat depth definitions are described at 40 cm in England and Wales and 50 cm in Scotland and Northern Ireland.[184] • Wetlands: areas of marsh, fen, peat, and or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.
	Rationale: • Definitions for woodland align with the **National Forestry Inventory definition** of woodland.[185] • Wetlands are defined as per Article 1.1 of the **Ramsar Convention** on Wetlands.[186] • Peatlands – when degraded, peatlands release large amounts of CO_2 and CH_4 into the atmosphere. While covering only **0.4%** of the world's land, drained peatlands emit over **5%** of global anthropogenic carbon emissions[187]. In the UK, peatlands are now a significant net source of GHG – emitting approximately 16 million tonnes of CO2e each year (2023)[188]. Preventing further damage can therefore play an important role in climate regulation within the UK and globally. Research from Roe et al. (2019)[189] estimates that **reducing peatland conversion in the UK could deliver 1.15 $MtCO_2e\ yr^{-1}$** by 2050. Peatland definitions in the UK are taken from the UK Centre for Ecology & Hydrology.[190]
Harmful intensification of	**Space allowances and stocking densities**[191] – refer to Appendix I for further detail • **Broiler chickens** ○ Broilers should be kept with a maximum stocking density of $11kg/m^2$ • **Laying hens**

[184] Centre for Ecology & Hydrology (2017) Implementation of an Emissions Inventory for UK Peatlands
[185] National Forestry Inventory (2021) Woodland England 2020
[186] UNESCO (1994) Ramsar Convention on Wetlands of International Importance
[187] IPPC (2019) Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security and Greenhouse Gas Fluxes in Terrestrial Ecosystems.
[188] IUCN (2023) Peatland code
[189] Roe et al. (2019) Contribution of the land sector to a 1.5 °C world
[190] Centre for Ecology & Hydrology (2017) Implementation of an Emissions Inventory for UK Peatlands
[191] LNAS members considered existing guidance and standards to potentially use as proxy for alignment to the TSC such as Red Tractor and Soil Association Organic Certification. LNAS members agreed that the focus of the TSC should be on outcomes, and that using specific certifications or standards may both exclude businesses which are delivering on the environmental objectives and give the impression that these certifications necessarily imply environmental sustainability.

livestock is prevented	◦ **Enclosure area**
	◦ For laying hens, pullets aged 6 weeks and older and layer breeders, in group sizes over 30 birds, minimum enclosure surface area is **80 m^2**
	◦ For group size under 30 birds, minimum surface area of **25 m^2**
	◦ **Stocking densities**
	◦ Laying hens should be kept with a maximum stocking density of **4 hens/m^2**
	◦ Pullets should be kept with a maximum stocking density of **15 pullets/m^2** until the end of the rearing period
	• **Housed cattle**
	◦ At a minimum, 9m^2 of space per cow should be provided in indoor housing
	◦ Cubicle systems must have at least one cubicle per animal. Cubicles must:
	  ◦ be long enough and wide enough to allow comfortable rest without injury – but short enough to prevent fouling in the bed and narrow enough to prevent turning around or lying at angles.
	  ◦ accommodate the natural rising of the animal and not cause the animal injury as it rises
	  ◦ Cubicle size should be determined by the size of the animal using the dimensions set out in Appendix I
	◦ Group housing systems (including corrals) must be of sufficient size to allow all livestock to lie down simultaneously, ruminate, rise, turn around and stretch without difficulty.
	• **Calves**
	◦ Calves kept in individual stalls should be given **at a minimum of 6 m^2.**
	◦ Calves kept in individual stalls, pens or hutches (except for those in isolation) must be allowed direct visual and tactile contact with other calves (where there are 2 or more calves on-farm).
	◦ Calves kept in group housing should be given **at a minimum of 3 m^2 per calf.**
	• **Sheep** – during winter or in inclement weather sheep should be housed with minimum space allowances set out in Appendix I
	• **Pigs** – Minimum space allowances are set out in Appendix I. Additionally, pigs should be housed in a way which allows them enough space for separate lying and dunging areas and for lateral lying in high temperatures.

Rationale: LNAS members firmly agree that criteria are needed to ensure the protection of animal welfare and safeguard against emissions reductions being made through harmful intensification of livestock systems. This reflects the significant societal expectations for high animal welfare standards and the strong steer from the market that the taxonomy must consider animal welfare and not classify intensive livestock production as taxonomy-aligned without sufficient consideration of multiple ESG risks[192]. Intensively reared livestock has extensive adverse impacts on GHG emissions, biodiversity, water use and antimicrobial resistance, as well as causing eutrophication and soil degradation.

The LNAS Advisory Group has taken a consistent approach to proposing space allowances and stocking densities for different livestock species by aligning, where possible, with the European Food Standards Agency's (EFSA) scientific opinions on the welfare of animals on farm.[193] The EFSA releases scientific opinions at the request of the European Commission, European Parliament, Member States or on its own initiative to inform or respond to relevant legislation. The EFSA scientific opinions on the welfare of animals are developed using a harmonised methodology whereby the effect of an exposure variable (e.g. space allowances on farm) are quantified by comparing the expression of animal-based measure(s) (e.g. prevalence of tail biting in pigs) under 'unexposed conditions' (e.g. unlimited space) and under high exposure (e.g. restrictive conditions).[194]

Space Allowances and Stocking Densities:
Sufficient space allowances and stocking densities can help to protect animals from physical and thermal discomfort, fear and distress, and allow them to perform their natural behaviour.[195] Lower stocking densities can also help to ensure adequate access to food, particularly in grazing systems and reduce the environmental impacts of livestock production.[196] Stocking density can impact the ability of the surrounding environment to manage and integrate wastes by aligning with the carrying capacity of fields. Appropriate stocking density and space allowances help with animal health and can limit the need for antibiotic use and other medicinal interventions.

- **Broiler Chickens:** A SD of 11kg/m^2 is proposed in line with the European Food Standards Agency's Scientific Opinion on the welfare of broilers.[197] The EFSA found that 11kg/m^2 is the maximum stocking density above which foot pad dermatitis increases, walking ability is reduced and behavioural needs are impaired because of lack of space.

[192] FAIRR (2021) Investor letter to the European Commission, representing over $3.5 trillion in assets, on concerns over the proposed agriculture criteria
[193] European Food Standards Agency (2023) Animal Welfare
[194] European Food Standards Agency (2022) Methodological guidance for the development of animal welfare mandates in the context of the Farm to For Strategy.
[195] RSCPA (2017) Welfare Standards for Laying Hens
[196] Agriculture and Horticulture Development Board (AHDB) (n.d.) Establishing performance targets from rotational grazing for cattle
[197] European Food Standards Agency (2022) Welfare of broilers on farm.

	• **Laying Hens:** A SD of 4 hens/m^2 is proposed in line with the European Food Standards Agency's scientific opinion on the welfare of laying hens.[198] • **Housed Cattle:** Recommended space allowances for housed (dairy) cattle are taken from the European Food Standards Agency's Scientific Opinion on the Welfare of Dairy Cows.[199] Appropriate stocking densities for dairy cows can help manage mastitis and thus limit antibiotic use.[200] • **Calves:** Space allowances are taken from the European Food Standards Agency's Scientific Opinion on the Welfare of Calves.[201] For individually housed calves, 6 m^2 was estimated to allow calves to perform 15% of the 'full extent of locomotor play behaviour. Space allowances of 30 m^2 per animal would allow them to perform 100% of locomotor play behaviour. For four group-housed calves, space allowances of 3 m^2 were estimated to allow calves to perform 16% of full locomotor play behaviour while a space allowance of 20 m^2 would allow them to perform 100% of it.[202] Locomotor play behaviour is associated with positive affective states in calves and is an indicator of overall welfare as it indicates a low-stress condition without threats to welfare such as hunger, cold or fear.[203] • **Sheep:** Proposed space allowances for housed sheep are in line with Defra Code of Recommendations for the Welfare of Livestock: Sheep (2002).[204] • **Pigs:** Space allowances proposed in line with the European Food Standards Agency's Scientific Opinion on the welfare of pigs.[205]
Imported animal feed does not lead to land-use	Demonstrate a transparent approach to **confirming all feed substances** are not sourced from land which has undergone deforestation or any land use change which has caused a loss in biodiversity and carbon, no later than 2020: • The Round Table for Responsible Soy (RTRS) Standard for Responsible Soy Production[206] ensures zero deforestation and zero rainforest conversion in soybean production. • The ProTerra Standard[207] ensures no land use conversion and forest conservation for agricultural activities.

[198] European Food Standards Agency (2023) Welfare of laying hens on farm
[199] European Food Standards Agency (2023). Welfare of dairy cows.
[200] AHDB (2020) Mastitis Control Plan
[201] European Food Standards Agency (2023) Welfare of calves.
[202] (ibid).
[203] Bailey-Caumette, Bertelsen and Jensen (2023) Social and locomotor play behavior of dairy calves kept with the dam either full time or half time in straw-bedded pens.
[204] Defra (2002) Code of Recommendations for the Welfare of Livestock: Sheep
[205] European Food Standards Agency (2022). Welfare of pigs on farm.
[206] Round Table for Responsible Soy (2021) Standard for Responsible Soy Production V4.0
[207] ProTerra Foundation (2023) The ProTerra Standard v5.0

change or degradation	**Rationale:** The UK government will implement due diligence provisions to make it illegal for larger businesses operating in their respective jurisdiction to use forest risk commodities, including soy animal feed, produced on land illegally occupied or used[208]. The European Union Regulation on Deforestation-Free Products (EUDR)[209] will curb the entry of products linked to any deforestation and conversion into global supply chains. LNAS members agreed that the criteria should align with best practice and ensure consistency at the global level. A cut-off date of 2020 is given as this aligns with the global goals to halt deforestation by 2020—as specified in the New York Declaration on Forests[210] and in the United Nations Sustainable Development Goals (SDGs)[211]— the Science Based Targets Initiative's Forest, Land and Agriculture Guidance (SBTI FLAG),[212] and in the EUDR. This ensures consistency at the global level. Planet Tracker research found that the Round Table on Responsible Soy (RTRS) Standard for Responsible Soy Production scheme emerges as the best standard to certify deforestation-free soy feed whilst also being one of the largest certifiers, with Proterra also scoring scores highly.[213] When considering carbon that could be sequestered if the land was released from agriculture (COC), WWF analysis estimates that emissions associated with imported soy in the UK (this includes direct emissions but not transport emissions) are 20.1 Mt CO_2e yr^{-1} – this is nearly double than that from agriculture soil emissions (11 Mt CO_2e yr^{-1}).[214]
Improve or maintain grassland	**Minimise disturbance from renovation** Pasture renovation should be conducted in a way that minimises soil disturbance from ploughing and reseeding.
	Rationale: Minimising disturbance of the soil when renovating pasture can help maintain carbon stocks in the soil, improve soil structure and decrease emissions from machinery.[215] The definition of permanent grassland is taken from EU law as retained into UK law.[216]
	Maintain permanent grassland Permanent grassland is defined as land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for five years or more.

[208] Defra (2022) Implementing due diligence on forest risk commodities
[209] European Union (EU) (2023) Regulation (EU) 2023/1115 on deforestation-free products
[210] Forest Declaration Assessment (2014) New York Declaration on Forests
[211] United Nations (2017) Target 15.2 of the SDGs
[212] SBTi (2022) Forest, Land and Agriculture (FLAG) Guidance
[213] Planet Tracker (2022) Increased soy certification would decrease deforestation risk
[214] WWF (2022) Farm-level Interventions to Reduce Agricultural Greenhouse Gas Emissions
[215] Innovation for Agriculture (2021) Reducing greenhouse gas emissions at farm level.
[216] HM Government (2013) Art 4 (1h) of EU 1307/2013

	Rationale: Permanent grasslands are a significant store of carbon and in some cases can rival or exceed the carbon sequestration and storage potential of woodlands. In Britain, permanent grasslands have been estimated to store 2 billion tonnes of carbon to a depth of 100 cm while being highly sensitive to changes in land management.[217]
	Remove animals from soils which are fully saturated or when the soil has reached total soil water storage capacity.
	Rationale: Soil compaction can have a negative effect on grass growth, yield and quality, caused by a restriction in root depth, which reduces nutrient uptake, or because of the formation of waterlogged areas, this may, in turn, cause increased nitrogen losses[218]. Studies that focused on trampling (poaching) by animals have indicated production losses as high as 52% in severely poached areas and the persistence of the soil's physical damage[219]. Livestock can cause compaction by poaching wet ground, especially around high-activity areas like gateways, drinking troughs and feeders. In wetter soils, cattle cause hollows 10cm to 12cm deep. This can form an almost continuous layer of grey waterlogged soil. Sheep are less likely to break the soil surface, but in high numbers can produce a solid compaction layer 2cm to 6cm deep over a wide area.[220]
Emissions and leakage from slurry storage are reduced	**Cover slurry stores with an impermeable cover:** the Agriculture and Horticulture Development Board (AHDB) offers guidance on different types of slurry stores.[221]
	Rationale: It has been estimated that 75% of sediments polluting water bodies in the UK come from farming.[222] Covering slurry stores with an impermeable cover can significantly decrease emissions from slurry and the risk of manures escaping into the environment. Scotland's Rural College (SRUC) estimated that across the UK, covering slurry stores with an impermeable plastic cover could reduce emissions by 126.7 kT CO_2e y^{-1}.[223] At a farm level, using an impermeable plastic cover could reduce N_2O emissions by 100%, NH_3 emissions by 80% and the CH_4 conversion factor by 47% compared with an uncovered slurry store.[224]
Carbon stock in farmland trees is maintained	**Maintain and regenerate trees along field boundaries.** Field boundaries include hedgerows and hedgebanks, drystone walls and ditches. Trees can be lines of trees or shrubs, where scrubby hedges have been allowed to grow unchecked and standard trees that have been specifically planted or selected to develop to maturity.

[217] Ward et al. (2022) Legacy effects of grassland management on soil carbon to depth.
[218] University of Minnesota Extension (2018) Soil Compaction
[219] College of Agriculture, Food and Rural Enterprise (n.d.) Avoiding Soil Compaction
[220] Defra (n.d.) Remove soil compaction
[221] AHDB (n.d.) Benefits of covering slurry stores.
[222] Global Food Security Programme (n.d.) Agriculture's impact on water quality.
[223] Scotland's Rural College (SRUC) (2020) Non-CO2 abatement in the UK agricultural sector by 2050
[224] (ibid).

	Guidance for sustainable management of trees along field boundaries can be found: • Defra: Plant and manage hedgerows[225] • Defra: Maintain trees along field boundaries[226] • Natural England: Hedge cutting[227] • Hedge Link[228]
	Rationale: Soils under hedgerows store a significant amount of carbon. A project by the University of Leeds found that soils beneath hedgerows stored on average 31% more carbon than in adjacent grass fields, with old hedgerows (planted over 37 years ago) storing 57% more.[229] Maintaining existing hedgerows is key to maintaining existing carbon stores. Hedgerows can have additional benefits such as reducing soil erosion and flood risk, providing forage and shelter for livestock and wildlife, and linking habitats allowing wildlife to move across the landscape, especially if the hedge contains mature trees.[230] Additionally, the Climate Change Committee (CCC) recommended that the length of hedgerows will need to increase by 40% in the UK to contribute to the country's net zero targets.[231] See Table 4a for suggested optional practices related to agroforestry.

Table 3: The following table outlines the proposed quantitative approach to demonstrate sufficient progress towards alignment with 1.5^{0}C. No single trajectory has been defined for UK agricultural emissions reductions. Instead, an accompanying analysis paper provides an in-depth evaluation of several trajectory options to inform future target-setting by HMG.[232] Until such a target is set, LNAS recommends that HMG adopt the Science-Based Targets Initiative's Forest, Land, and Agriculture (SBTi-FLAG) tool as the best available option that meets LNAS requirements for an agriculture emissions reduction target. These requirements are alongside the minimum baseline practices set out in Table 1, and prior to the mandatory DNSH assessment in Table 5. Optional approaches to support emissions reductions and carbon sequestration are set out in Tables 4a and 4b.

[225] Defra (n.d.) Plant and Manage Hedgerows
[226] Defra (n.d.) Maintain trees along field boundaries
[227] Natural England (2007) Hedge cutting: answers to 18 common questions
[228] Hedge Link (n.d.) Resources
[229] Biffi et al. (2022) Soil carbon sequestration potential of planting hedgerows in agricultural landscapes. Journal of Environmental Management, 307.
[230] Defra (n.d.) Plant and manage hedgerows.
[231] CCC (2020) Land Use: Policies for a Net Zero UK
[232] GFI, LNAS (2024) "Supplementary paper: Options for defining reductions in agricultural emissions for the UK Green Taxonomy

Environmental Outcome	**Table 3: Livestock production** Demonstrate a Substantial Contribution to Climate Change Mitigation
Substantial avoidance or reduction in GHG emissions is demonstrated and long-term carbon sequestration is maintained	1. **Percentage reduction of cradle to farm-gate GHG emissions and increases in biogenic carbon removals** (gCO_2e) on the whole farm holding against a baseline year. The reduction target should: • Be sufficient to demonstrate progress towards 1.5°C alignment; • Cover cradle to farm-gate emissions to include upstream emissions from fertiliser production[233] and livestock feed production;[234] • Allow for a baseline based on historical data, if a farm has made substantial emissions reductions prior to the baseline year. • Incentivise practices that increase on-farm biogenic carbon removals. 2. Above and below ground carbon stocks ($tCha^{-1}$) at the farm level to be maintained or increased progressively over a minimum 20-year period. IPCC guidance indicates that sampling soil carbon stocks should be done at depths of 0-30, 30-60 and 60 cm and beyond, as a 30 cm assessment does not take account of potential soil carbon sequestration deeper in the soil profile. **OR** Agriculture companies who have set near-term and net zero targets through the Science Based Targets Initiative's Forest, Land and Agriculture (SBTi- FLAG) guidance[235] and tool[236] can be considered taxonomy aligned. FLAG targets must be verified and cover emissions and removals up to the farm gate.

[233] Inorganic (or synthetic) fertiliser production emissions are attributed to the energy requirements (CO_2) and use of natural gas in the production process along with the production of nitric acid (as a stage to producing ammonium nitrate) and the leakage of N_2O.
[234] Feed production emissions are attributed to soil management, land-use change (LUC), and fertiliser production, as well as electricity use during drying and processing.
[235] SBTi (2022) Forest, Land and Agriculture (FLAG) Guidance
[236] SBTi (2024) FLAG Target Setting Tool

	Rationale: **Quantitatively demonstrating progress in reducing CO2e emissions:** LNAS agreed that a UK farm manager or business owner seeking alignment with the UK Green Taxonomy will need to quantitatively demonstrate progress in reducing CO_2e emissions that is sufficient for Paris alignment or demonstrate that the farm operating in a way that is already Paris aligned. The scope should include cradle to farm-gate emissions, incorporating upstream emissions from fertiliser production and livestock feed, as well as on-farm emissions from soil management, livestock and energy use. The accompanying analysis paper provides an in-depth evaluation of several trajectory options to inform this target-setting by HMG.[237] **Carbon sequestration:** No absolute threshold is set for carbon sequestration given the variability of carbon sequestration and stocking potential. Nor is a specific % of carbon increase defined given the possibility of rewarding an underperforming farm through a relative target. Therefore, the proposal requires evidence of a positive direction of travel in terms of increasing carbon stocks, with the optional best practice guidance offering practices to increase carbon sequestration. This is based on Smith et al (2007)[238] estimates that 89% of the technical potential of emission reductions in the sector to 2030 and 2050 lies in soil carbon sequestration, i.e. in reducing net CO_2 emissions. A Roe et al. (2019) review estimates that the technical potential of UK agriculture soil carbon sequestration is at 10.98 $MtCO_2e\ yr^{-1}$. A 20-year period for carbon stock saturation maintenance is proposed in line with the IPCC 20-year soil carbon saturation period. **SBTi's FLAG guidance and tool:** The Science-Based Targets Initiative's Forest, Land, and Agriculture (SBTi-FLAG) tool provides a robust and scientifically validated method for setting GHG reduction targets in the land-use sector, including agriculture. The tool was developed using resources from the IPCC and is based on pathways outlined in Roe et al. (2019) [239] and Smith et al. (2016)[240] offering a sector-specific approach to align agricultural activities with a 1.5°C target. The SBTi-FLAG tool covers both emissions and biogenic removals associated with land use up to the farm gate. This includes emissions from livestock feed (land-use change, feed production) and fertiliser use, as well as carbon removals through on-farm activities such as soil carbon enhancement and agroforestry. The accompanying analysis paper provides further analysis of the SBTi-FLAG tool and recommendations for HMG.[241]

[237] GFI, LNAS (2024) "Supplementary paper: Options for defining reductions in agricultural emissions for the UK Green Taxonomy
[238] Smith et al. (2007) Greenhouse gas mitigation in agriculture
[239] Roe et al. (2019) Contribution of the land sector to a 1.5 °C world
[240] Smith et al. (2016) Science-Based GHG Emissions Targets for Agriculture and Forest Commodities
[241] GFI, LNAS (2024) "Supplementary paper: Options for defining reductions in agricultural emissions for the UK Green Taxonomy

Table 4a: The below farming management practices have been researched, tested, and implemented with a substantial body of scientific evidence supporting their effectiveness in reducing GHG emissions and sequestering carbon. These practices are not mandatory but are meant to act as best practice guidance for farmers that are aiming to decrease their GHG emissions and increase carbon sequestration to become taxonomy-aligned. These practices may be seen as complementary to the mandatory requirements to substantially contribute to climate change mitigation, set out in Table 1, Table 2 and Table 3.

The majority of the emission reduction practices pertain to methane reductions. In 2020, agriculture was responsible for 48% of methane territorial emissions in the UK, coming primarily from enteric fermentation and manure management. Other emissions reduction practices pertain to nitrous oxide and carbon dioxide from livestock management, farm machinery and embedded emissions in animal feed and fertiliser.

Table 4a: Livestock production – approaches for farmers Well-evidenced management practices to reduce GHG emissions and increase carbon sequestration	
Practice Description	**Rationale**
Animal feed and diet • **Precision and multi-phase feeding techniques**. Adopt precision feeding techniques where the nutrient requirements of groups of animals or individual animals are precisely targeted during feed formulation. This practice is primarily suitable for housed animals which can be monitored at regular intervals, with the information used to adjust feed rations.	According to the Climate Change Committee (CCC), enteric fermentation, primarily methane, accounts for 49% of agricultural emissions and 70% of livestock emissions in the UK.[242] Research from Roe et al. estimates the mitigation potential of reducing emissions from enteric fermentation in the UK (10% from intensive and 70% from extensive) to be at 7.96 $MtCO_2e\ yr^{-1}$ by 2050.[243] **Precision and multi-phase feeding techniques:** Precision feeding can reduce the feed conversion ratio of animals, with decreased GHG emissions from feed production made possible by decreasing the amount of food required in the system. Nitrogen and volatile solid excretion can also be reduced which will in turn reduce N_2O and CH_4 emissions[244]. SRUC estimates precision feeding can reduce the gross energy requirement of

[242] CCC (2023) Progress in reducing emissions - 2023 Report to Parliament - Charts and data
[243] Roe et al. (2019) Contribution of the land sector to a 1.5 °C world
[244] Scotland's Rural College (SRUC) (2020) Non-CO2 abatement in the UK agricultural sector by 2050

• **Incorporate high sugar-content grasses into pasture: The** incorporation of high sugar grasses is a management option for pasture-based livestock systems. High sugar-content grasses are ryegrass varieties bred for high concentrations of water-soluble carbohydrates which can increase the efficiency of the use of N released from digested forage.	dairy cows by 2% and the nitrogen and volatile solid excretion of pigs by 2%.[245] **High sugar-content grasses:** When digested by ruminants, high sugar-content grasses can increase the efficiency of the use of nitrogen released from digested forage, decreasing the proportion of nitrogen which is lost in urine, resulting in a reduction of nitrogen lost to the environment and N_2O emissions.[246] SRUC estimates this practice could yield UK-wide emissions reductions of 54.2 kt CO_2e yr^{-1}.[247]
Limit the use of imported animal feed and fertiliser through integrated farming • Maximise feed produced on-holding, either grazed or cut from grasslands, or as agroecological outputs such as catch crops, cover crops, forage cut from living trees and shrubs, vegetation from nature-based solution water treatments such as algae or duckweed. • Minimise the feed coming from off-holding and wherever possible should be acquired from local sources such as in cooperation with other farmers. • Any imported feed should comply with the animal feed minimum baseline requirements in Table 1.	Livestock and their feed account for 85% of the UK's total land use for agriculture (both domestically and internationally), including 850,000 hectares abroad used for feed for livestock in the UK.[248] Integrating crop and livestock within the UK can decrease reliance on imported feed and reduce the embedded emissions and other impacts of land use from UK livestock production. Integrated crop-livestock systems allow for effective nutrient cycling and increased energy efficiency.[249] Efficient on-farm nutrient cycling can decrease reliance on external inputs (feed and fertiliser) and reduce run-off and emissions from application of nitrogen fertilisers on cropland, grassland or pasture. A study in China on smallholder farms found that combining crop and livestock production could reduce emissions intensity by 17.67% with the system producing its feed and returning manure to the field being an essential pathway.[250] Crop-livestock integration has been observed to

[245] (ibid).
[246] Eory et al (2020) *CO_2 abatement in the UK agricultural sector by 2050: Summary report submitted to support the 6th carbon budget in the UK*
[247] Eory et al. (2020) Non-CO2 abatement in the UK agricultural sector by 2050
[248] World Wide Fund for Nature (2022) The Future of Feed: How low opportunity cost livestock feed could support a more regenerative UK food system.
[249] Entz et al. (2005) Evolution of integrated crop-livestock production systems
[250] Xu et al. (2023) Coupling of crop and livestock production can reduce the agricultural GHG emission from smallholder farms

• Manure generated from livestock should be used as fertiliser for crops and pasture.	increase soil organic carbon (SOC) stocks, improving soil fertility and structure while sequestering carbon.[251]
Manure Management • **Separating solids from slurry:** Mechanically or chemically separate the liquid portion of slurry, which is typically rich in nitrogen (N_2), from the solid part, which contains phosphorus and volatile solids. This separation can optimise nutrient management and reduce methane emissions. • **Composting and applying solid manure:** Composting is a process where microorganisms transform organic matter into CO2 and water under aerobic conditions.[252] The resulting compost can be applied as a nutrient-rich soil amendment, contributing to soil health and fertility. Manure can either be left to compost undisturbed, mechanically turned or actively aerated. • **Cooling of liquid manure:** Employ cooling techniques to reduce the temperature of liquid manure. This practice is often bundled with other low-emission spreading measures. • **Apply low-emission application technology for slurry:** Low-Emission Slurry Spreading Equipment (LESSE), including dribble bar, trailing horse, trailing shoe, soil incorporation and soil injection methods of slurry application.[253]	According to the CCC, wastes and manure management – primarily methane and nitrous oxide – is responsible for **14% of UK agricultural emissions.[254]** The storage and application of manures to land are responsible for 30% of all UK livestock emissions. **Separating solids from slurry:** Volatile solids pertain to the organic matter content of a liquid or slurry, which is highly related to the source of methane emissions[255]. Separate storage of solid and liquid fractions has typically been found to result in lower CH_4 emissions and lower combined CH_4 and N_2O emissions than from untreated slurry. However, post-separation manure management will impact the extent to which emissions are lowered. Covering slurry stores and anaerobic digestion of manures are options for ensuring decreased emissions.[256] **Composting and applying solid manure:** Composting solid manure helps stabilise organic matter and reduces methane emissions during storage. Combined CH_4 and N_2O emissions have been found to be lower after forced aeration and mechanical turning compared with passive composting.[257]

[251] Liebig et al. (2021) Integrating beef cattle on cropland affects net global warming potential
[252] Peterson (2013) Manure management for greenhouse gas mitigation.
[253] DAERA (2020) The application of low emission slurry
[254] CCC (2023) Progress in reducing emissions - 2023 Report to Parliament - Charts and data
[255] Qu and Zhang (2021) Effects of pH, Total Solids, Temperature and Storage Duration on Gas Emissions from Slurry Storage: A Systematic Review
[256] Peterson (2013) Manure management for greenhouse gas mitigation.
[257] Peterson (2013) Manure management for greenhouse gas mitigation.

	Cooling liquid manure: Lowering the temperature of liquid manure can help decrease methane emissions during storage and handling. **Apply low-emission application technology:** The act of spraying liquid into the air using broadcast (splash plate) application methods results in much of the nitrogen in the fertiliser reacting with the air and forming ammonia and less remaining in the material to fertilise crops.[258] Utilising LESSE methods can decrease emissions while increasing the amount of nitrogen available for fertilisation. This can decrease the amount of slurry needed and reduce nutrient loss into the environment.
Introduce legumes into pasture: Pastures should incorporate legume mixtures on pasture, such as white and red clover. To have maximum GHG reduction impact, the legumes should account for 20-30% of the sward mix.	The nitrogen fixing properties of legumes can help to facilitate a reduction in GHG emissions on farm by reducing the inorganic fertiliser requirement. The addition of legumes to a grass pasture is of further benefit to livestock through an increase in protein content, improved palatability of the pasture and for the anthelmintic properties of legumes. Key pasture legumes include White Clover; Red Clover; Lucerne; Sainfoin; Birdsfoot Trefoill; and Vetches.[259] Research by Roe et al. (2019)[260] estimates that the **mitigation potential of grazing legumes in the UK at 8.53 MtCO2e yr^{-1}**
Agroforestry and Silvopasture systems Integrating trees in pasture lands which **are not woodland.** Integrating trees on farms which are not woodland (namely not land spanning more than 0.5 hectares in an area).	The IPPC AR6 report a medium confidence that agroforestry has a technical potential of 4.1 (0.3–9.4) GtCO$_2$e yr^{-1} for the period 2020–2050. Despite uncertainty around global estimates due to regional preferences for management systems, suitable land availability, and growing conditions, there is **high confidence** in agroforestry's mitigation potential at the field scale.[264]

[258] Defra (2018) Code of Good Agricultural Practice (COGAP) for Reducing Ammonia Emissions
[259] (ibid).
[260] Roe et al. (2019) Contribution of the land sector to a 1.5 °C world
[264] IPCC (2022) 6th Assessment Report

• **Silvopastoral agroforestry** is the integration of trees with livestock, encompassing wood pasture, grazed orchards and silvopastoral systems which combine trees, crops and livestock.[261] • **Hedgerows, shelterbelts and riparian strips** are forms of agroforestry where trees are grown between, rather than within parcels of land. Trees should be grown for optimal growth and survival, for a minimum of 10 years, and incorporate native and diverse species. For maximum environmental benefits trees should be grown for a minimum of 30 years.[262] For further guidance refer to Defra's agroforestry ELMs actions.[263]	The CCC estimates that agroforestry, including expanding hedgerows and silvoarable systems, could deliver 6 $MtCO_2e$ of savings by 2050 and recommends that 15% of current grasslands should be converted into silvopastoral systems.[265] Agroforestry also offers numerous co-benefits. In the UK, silvopastoral agroforestry can benefit animal welfare through shade and shelter provision, enhance nutrient cycling, improve air quality by capturing pollutants, offer habitat for pollinators and wildlife, reduce soil erosion and enhance water retention.[266][267] Silvopastoral agroforestry can also increase total yields and profitability, hens ranging on land with 20% tree cover have been found to have increased laying rates and higher shell density[268] and farm managers can benefit from diverse agricultural income streams through, for example, fruit and nut trees and sustainable timber production.[269]
Increase carbon storage in low productivity and degraded land: Convert low-grade, unprofitable land into higher-carbon habitats, including:	Converting low productivity or marginal land into woodland can significantly increase a farm's carbon sequestration capacity whilst generating co-benefits for the wider farming system.[273] Well-designed woodland can have a beneficial impact on food production by improving soil health, managing water resources and improving

[261] Soil Association (2019) The Agroforestry Handbook
[262] Burgess et al. (2022) The Potential Contribution of Agroforestry to Net Zero Objectives
[263] Defra (2024) Technical annex: The combined environmental land management offer
[265] CCC (2020) Sixth Carbon Budget report
[266] CEH and Rothamsted Research (2018) Quantifying the impact of future land use scenarios
[267] Palma et al. (2007) Modelling environmental benefits of silvoarable agroforestry in Europe
[268] Bright and Joret (2012) Laying hens go undercover to improve production
[269] CEH and Rothamsted Research (2018) Quantifying the impact of future land use scenarios
[273] The Forestry Commission (2023) The benefits of woodland creation.

Woodland is land spanning more than 0.5 hectares in area with trees having the potential to reach a height of at least five metres and a canopy cover of more than 20%.[270] **Scrub/scrubland** **Rewetting peatlands in lowland grassland:** • Peat restoration of lowland grassland involves rewetting the peat by restoring and maintaining water levels to significantly slow the rate at which peat is being lost. Research and field studies recommend that the water depth table for grassland be raised from -50 cm to -25cm.[271] • Guidance for rewetting raising water levels on grassland on peat soils includes Defra's countryside stewardship grant.[272]	biodiversity. Woodland can also make a farming business more resilient by providing an additional income stream from timber, carbon units or other forest-based commodities such as fruits and nuts.[274] In areas which are unsuitable for woodland creation, scrubland, multi-species meadows or other habitats can increase sequestration potential while providing habitats for wildlife. **Peatland restoration** In the UK, peatlands are now a significant net source of GHG, emitting 23.1 $MtCO_2e\ yr^{-1}$.[275] While peatlands converted to grassland occupy just 8% of the UK's peat area — approximately 100,000 ha of peat area is in grassland for livestock and/or silage production[276] — they are responsible for 27% of total UK peat emissions. Drained intensive grasslands in lowland areas are the primary source of these emissions.[277] Healthy peats store vast amounts of carbon - the CCC's net zero balanced pathway recommended that 50% of lowland peat grassland should be rewetted by 2050 to reach UK net zero.[278] • The key driver of managed peatland GHG emissions is the depth of the water table. In many cases rewetting brings back key peat forming vegetation within 5 to 10 years.[279]

[270] National Forestry Inventory (2024) Woodland England 2020
[271] Evans et al. (2023) The future of vegetable production on lowland peat
[272] Rural Payments Agency and Natural England (2022) SW18: Raised water levels on grassland on peat soils
[274] The Forestry Commission (2021) It's time to branch out: How woodland creation benefits your farm
[275] Evans et al. (2017) Implementation of an emission inventory for UK peatlands
[276] Approximately 150,000 is cropland which includes peat areas cultivating vegetables, cereals, oilseed rape and maize. See: Evans et al. (2023) The future of vegetable production on lowland peat
[277] Evans et al. (2017) Implementation of an emission inventory for UK peatlands
[278] CCC (2021) Sixth Carbon Budget report
[279] IUCN (2022) UK Peatland Restoration demonstrating success

Table 4b: The below set of farming management practices are emerging and less established, with less scientific validation or a shorter track record of successful adoption. While promising, they may require further research, testing, piloting, investment, and regulatory revision to be widely accepted. These practices are not mandatory but are meant to act as guidance for farmers who are aiming to decrease their GHG emissions and increase carbon sequestration to become taxonomy-aligned. These may be seen as complementary to the mandatory requirements to substantially contribute to climate change mitigation, set out in Table 1, Table 2 and Table 3.

Practices in Table 4b should be expected to move into Table 4a in future iterations of the UK Green Taxonomy, as part of the review process.

Table 4b: Livestock production - Approaches for farmers Emerging or innovative management practices to reduce GHG emissions and increase carbon sequestration	
Practice Description	**Rationale**
Animal Feed • **Methane suppressing feed products:** Implement the use of feed products with proven safety and efficacy, that have shown the ability to decrease enteric methane (CH_4) emissions in ruminants. Follow user instructions to maximise efficacy and prevent potential negative health effects on the livestock. • **Genetic selection of breeding livestock for methane emissions** reduction. Promote the genetic selection of breeding livestock that exhibit reduced methane emissions.	Feed additives Adding small quantities of specific additives to ruminant feed can reduce methane production without substantially changing diets. A range of products including methanogenesis inhibitors, seaweeds, essential oils, organic acids, probiotics, and antimicrobials have demonstrated methane suppressing properties. **Genetic selection** Studies suggest that the genetics of mammals influences the micro-organisms present in the gut.[282] Research commissioned by the CCC to assess the assess the abatement potential of on-farm measures[283], found that it is possible to select sheep for high or low CH_4 emissions, as CH_4 production is heritable to some extent; selection for low emission causes changes in the animal's

[282] Hegarty and McEwan (2010) Genetic Opportunities to Reduce Enteric Methane Emissions from Ruminant Livestock
[283] SRUC (2020) Non-CO2 abatement in the UK agricultural sector by 2050

Feed additives approved for use in the UK can be found in the Food Standards Agency.[280] Further information on existing and near-to-market additives can be found in a report by SRUC.[281]	nutritional physiology. The research found that genetic selection for low CH_4 emission for dairy cattle is possible too. However, might this limit productivity and fitness improvements to some extent. • Farmers can refer to the Defra and AHDB-funded Beef Feed Efficiency Programme for further developments on improving the efficiency of feed in beef cattle.[284] [285] For sheep, farmers can refer to the Defra-funded Breed for Ch4nge programme being delivered by Innovate UK.[286]
Manure Management • **Slurry acidification:** introduce acids to the slurry to achieve a pH range of 4.5-6.8. This controlled acidification significantly reduces both methane and ammonia emissions. Adjusting the pH level can create conditions that inhibit the microbial processes responsible for these emissions.	**Slurry acidification:** It has been estimated that 67-90% of manure CH_4 emissions can be avoided when applying strong acids to slurry such as sulphuric or hydrochloric acid. Acidification can be done at any phase of manure management: in the animal house, in the storage tank or before field application.[287]
Incorporate low carbon machinery, heating and cooling into farm systems If on-farm emissions from machinery make a significant contribution to the farm's overall emissions, switching to low carbon farm machinery and low carbon heating and cooling are options farms may consider.	According to the Defra, stationary and mobile combustion accounts for 11% of on-farm emissions.[290] The CCC has estimated that energy use from static and mobile machinery on farms has increased by 14% since 2008.[291] Although most agricultural emissions are N_2O and CH_4 from crop and livestock management, some farming businesses may have significant CO_2 emissions from machinery, heating and cooling.

[280] Food Standards Agency (2020). Animal feed additives.
[281] SRUC (2023) Existing and near-to-market methane reducing feed additives and technologies: Evidence of Efficacy, Regulatory Pathways to Market and Mechanisms to Incentivise Adoption
[284] AHDB (n.d.) Beef Feed Efficiency Project
[285] Defra Science Research (2014) Beef Feed Efficiency Programme: Improving the sustainability and competitive position of the UK beef industry through selective breeding
[286] National Sheep Association (2023) The sheep sector's path to net zero begins with new innovative project
[287] Eory et al. (2020) Non-CO_2 *abatement in the UK agricultural sector by 2050*
[290] Defra (2020) Agricultural Statistics and Climate Change 10th edition
[291] Baker et al. (2022) Decarbonisation of mobile agricultural machinery in Scotland – an evidence review

Low carbon machinery will likely be electric, with hydrogen-powered machinery potentially being developed in the future. This practice involves replacing fossil fuel use for heating and cooling with low-carbon and renewable alternatives. This would primarily mean replacing boilers with heat pumps, which require electricity. Heat pumps redirect waste heat from other processes (e.g., nearby wastewater treatment plants) and can also work well with on-site or nearby anaerobic digesters. **Explore on-farm energy production through agrivoltaics** Agrivoltaics refers to the integration of solar panels into an agricultural system.[288] Solar panels are installed elevated above crops or livestock, so the system produces energy alongside livestock. Farmers can refer to SolarPower Europe's best practice guidance for case studies and guidelines for implementation.[289]	Using low carbon fuels such as electric or biomethane or using low carbon heating and cooling means burning less fossil fuel, therefore reducing GHG emissions.[292] In its Balanced Net Zero Pathway, the CCC acknowledges low take-up of low carbon machinery but assumes biofuels and electrification options are taken up widely from the mid-2020s and hydrogen fuel cells for larger applications from 2030 for mobile machinery.[293] **Note:** If electricity to power new machinery comes from the grid, the emissions reduction potential will depend on the fuel mix used to produce electricity.[294] **Explore on-farm energy production through agrivoltaics** Agrivoltaic systems can contribute to climate change mitigation by producing renewable energy without displacing agriculture. Agrivoltaic systems typically supply the host farm with energy and sell the excess back to the grid (this opportunity is dependent on accessibility to the grid which can be challenging in some rural contexts). Incorporating agrivoltaics into farming systems can help improve business resilience of farms by diversifying income streams. Additionally, energy produced on farms can decrease energy costs for farmers, protecting them against volatility in the global energy market. Agrivoltaics can offer additional benefits for animal welfare as the solar panels provide shade and shelter for livestock. Incorporating solar panels with sheep production is relatively well established.[295] More research is needed to determine how best to incorporate solar panels into other livestock systems.

[288] Trommsdorff et al. (2024) Agrivoltaics: Opportunities for Agriculture and the Energy Transition
[289] SolarPower Europe (2023) Agrisolar Best Practice Guidelines.
[292] Innovation for Agriculture (2021) Reducing Greenhouse Gas Emissions at Farm Level
[293] CCC (2020) The sixth carbon budget methodological report.
[294] Eunomia & Innovation for Agriculture (2021) Farm-level Interventions to Reduce Agricultural Greenhouse Gas Emissions
[295] Handler and Pearce (2022) Greener sheep: Life cycle analysis of integrated sheep agrivoltaic systems

Table 5: How to demonstrate compliance

To demonstrate compliance it will be necessary to:
• Deploy all minimum baseline management practices, including a **GHG protocol compliant GHG emissions assessment.**
• The carbon stock and GHG emission baseline should include:
  ○ CO_2 emissions and removals in above and below-ground biomass and soils
  ○ CO_2, N_2O and NH_3 emissions from exposed soils, fertiliser application, and those embedded in fertiliser production and fertiliser application
  ○ CH_4 emissions from livestock (enteric fermentation and manure management) and some soils (e.g. wetlands)
  ○ CO_2 emissions from energy use
  ○ Develop a **carbon management plan** to set out the management practices that will deliver the GHG emissions reduction / increased carbon sequestration.
• The GHG assessment must be formally reported and verified every three years. Farmers can voluntarily report their GHG assessment year on year.

Table 6: Do No Significant Harm (DNSH) is the second of the tests an activity must show it meets in order to be deemed taxonomy-aligned. The below DNSH criteria will set out how crop production does not significantly harm any of the other five environmental objectives while making a substantial contribution to climate change and mitigation. Crop production can have significant environmental impacts outside of climate change that need to be considered for investments in the sector. Based on that understanding, LNAS suggests the DNSH criteria could include the below list of potential impacts against the other five environmental objectives:

- Climate change adaptation: The ability of farming systems to adapt to climate change
- Sustainable use and protection of water and marine resources: Impact on water quantity, water quality and water ecosystems
- Transition to a circular economy: Pollutant and nutrient runoff and leaching
- Pollution prevention and control: Impacts on air quality
- Protection and restoration of biodiversity and ecosystems: Impact on habitats and species

It should be noted that GTAG set out a series of recommendations to the UK government on how to approach the development of DNSH criteria in the UK Green Taxonomy, in its August 2023 paper on this topic.[296] There have been usability issues observed in DNSH criteria in other jurisdictions to date, which include issues due to the drafting of the criteria themselves, and GTAG provided advice on potential ways to fix these issues. Therefore, LNAS recommends that the DNSH criteria for livestock production be fully developed once the UK government has clarified its approach to DNSH in the UK Green Taxonomy. As such, this table sets out guidance as to what LNAS considers the primary issues that the final DNSH criteria for crop production should address, but LNAS has not proposed the final wording for the criteria at this stage, pending the UK government's clarification of its way forward on DNSH.

Table 6: Do No Significant Harm (DNSH) criteria	
Climate Change Adaptation	• LNAS recommends that the UK government develop the DNSH criteria for climate change adaptation once the UK government has clarified its approach to adaptation in the UK Green Taxonomy.
Sustainable use and protection of water	• Identify and manage risks related to water quality and/or water consumption and develop a water management plan to minimise risks. • Animal feed used should not have a significant water footprint.
Transition to a circular economy	• Activities should use residues and by-products and take any other measures to minimise primary raw material use per unit of output, including energy. • Activities should minimise the loss of nutrients from the production system into the environment.
Pollution prevention and control	• Where manure is applied to the land, activities should comply with the limit of 170kg nitrogen application per hectare per year. • Ensure that mitigation and emission reduction techniques for feeding and housing livestock and manure storage and processing are applied. This can be delivered through the practices set out in Table 3.
Protection of Healthy Biodiversity and Ecosystems	• Activities ensure the protection of soils, particularly over winter, to prevent erosion and run-off into water courses/bodies and to maintain soil organic matter. • Activities do not lead to conversion, fragmentation or unsustainable intensification of high nature-value land (See Biodiversity TSC for definitions of high-nature-value land).

[296] GFI, GTAG (2023) Streamlining and increasing the usability of the Do No Significant Harm (DNSH) criteria within the UK Green Taxonomy

	• Activities should not:[297] ○ result in a decrease in the diversity or abundance of species and habitats of conservation importance or concern; ○ contravene existing management plans or conservation objectives; ○ lead to overgrazing and other forms of degradation of grasslands.

1.4. Agriculture appendices

Appendix I: The space allowances set out below are required to align with a UK Green Taxonomy. Stocking densities have been proposed in line with the European Food Standards Agency's scientific opinions for housed cattle and pigs and the Defra Code of Recommendations for the Welfare of Sheep where an EFSA scientific opinion has not been developed.

Appendix I: Stocking Densities and Space Allowances		
Housed Cattle	**Design criteria**	**Dimensions**
	Cubicle Width	0.83 × cow height
	Cubicle Resting Length	1.1 × cow diagonal length
	Cubicle Length: head-to-head space sharing	1.8 × cow height
	Cubicle Length: non-space sharing cubicles (e.g. against a wall)	2.0 × cow height
	Neck rail height	0.80–0.90 × cow diagonal length

Pigs	**Weight of pigs in kg**	**Minimum space allowance when ambient temperatures do not exceed 25˚C & to maintain separate dunging and lying areas (m^2)**	**Minimum space allowance when ambient temperatures exceed 25˚C & for pigs weighing over 110kg (m^2)**
	10	0.17	0.22
	20	0.27	0.35
	30	0.35	0.45

[297] Retained from the EU (2020) TEG-recommended TSC for livestock production and consistent with HM Government (1992) Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild flora and fauna

	40	0.42	0.55
	50	0.49	0.64
	60	0.55	0.72
	70	0.61	0.80
	80	0.67	0.87
	90	0.72	0.94
	100	0.78	1.01
	110	0.83	1.08
Sheep	**Type of Sheep**	**Age**	**Space allotted (m^2)**
	Lowland ewes (60-90kg liveweight)	Ewe only	1.2 – 1.4 per ewe
		With lambs at foot	2.0-2.2 per ewe and lambs
	Hill ewes (45-65kg liveweight)	Ewe Only	1.0-1.2 per ewes
		With lambs at foot	1.8-2.0 per ewe and lambs
	Lambs	Up to 12 weeks	0.5-0.6 per lamb
		12 weeks to 12 months	0.75-0.9 per lamb
	Rams		1.5-2.0 per ram

1.5 Agriculture technical glossary

Agrivoltaics	The integration of solar panels into an agricultural system.
Agroforestry	The process of integrating trees into agricultural land which is not woodland.
Agroforestry (Silvoarable)	The integration of trees with livestock, encompassing forest grazing, wood pasture, orchard grazing, as well as systems which integrate trees, livestock and crops.
Aminomethylphosphonic acid (AMPA)	AMPA is one of the primary degradation products of the herbicide glyphosate.
Antibiotics/Antimicrobials	Antimicrobials – including antibiotics, antivirals, antifungals and antiparasitics – are medicines used to prevent and treat infections in humans, animals and plants.
Antimicrobial resistance	Antimicrobial resistance occurs when infectious agents (bacteria, viruses, fungi and parasites) evolve over time and acquire new characteristics that reduce or stop their susceptibility to antimicrobials. The inappropriate and excessive use of antimicrobials in animal production contributes to the development of AMR.
Biochar	Organic material that has been carbonised under high temperatures (300-1000°C), in the presence of little, or no oxygen.
Biosecurity	Measures to prevent the spread of disease on and between farms.
Carbon Opportunity Cost (COC)	The Carbon Opportunity Cost is the amount of carbon that could be sequestered if land was released from agriculture, or the amount of carbon that could be emitted if new land were brought into agricultural production.
Carbon sequestration	The process of capturing and storing atmospheric carbon dioxide. In the context of agriculture, this occurs via plant photosynthesis and is stored in above- and below-ground biomass and soils.
Cover crop	A close-growing crop that provides soil protection, seeding protection, and soil improvement between periods of normal crop production. Cover crops are meant to provide soil cover rather than leaving soil bare between cash crops.

Hedgerows	A hedge or hedgerow is a line of closely spaced shrubs, sometimes trees, planted and trained to form a barrier or to mark the boundary of an area, such as between neighbouring properties.
Herbal leys	Temporary grasslands made up of legume, herb and grass species.
Inorganic fertilisers	Fertilisers in which the declared nutrients are in the form of minerals obtained by extraction or by physical and/or chemical industrial processes. Inorganic fertilisers may also be known as ‘synthetic fertilisers’ or ‘chemical fertilisers.
Integrated farming	Producing both crops and animals on one farm holding.
Intensification	The process of modifying production practices to increase output per animal, per unit of land and per unit of labour.
Low Emission Slurry Spreading Equipment (LESSE)	Slurry spreading equipment reduces ammonia emissions and nitrogen loss from slurry. LESSE includes trailing hoses, trailing shoes and shallow injectors.
Lowland peatland	Lowland-raised bogs and fens fed by groundwater. Lowland peatlands are distributed across much of the UK, with the most extensive peat areas in the East Anglian Fens, Somerset Levels and in the lowlands of Northern England.
Metaphylactic	The treatment of a group of animals after the diagnosis of disease gas been made in part of the group. The metaphylactic use of antibiotics is to control the spread of infection.
Minimum tillage (Min-till)	Growing crops or pasture using mechanical methods other than ploughing. Machinery should not go deeper than 15 cm or turn over the soil.
Nitrification inhibitors	Decrease the activity of nitrifying bacteria and thus reduce conversion of ammonium to nitrate, which subsequently becomes denitrified to form N_2O.
Nitrogen Use Efficiency (NUE)	The ratio between the amount of fertiliser nitrogen applied and the amount of nitrogen that is removed with the harvest
No tillage (No-till)	Growing crops or pasture without the use of cultivation machinery. Farms instead plant crops through direct drilling.

Optional practice (innovative or emerging)	These practices are suggested management practices which farmers can choose to implement in order to deliver the required emissions reductions and carbon sequestration. These innovative or emerging practices have less scientific validation or a shorter track record of successful adoption. While promising, they may require further research, testing, piloting, investment, and regulatory revision to be widely accepted. These practices are not mandatory.
Optional practice (well-evidenced)	These practices are suggested management practices which farmers can choose to implement in order to deliver the required emissions reductions and carbon sequestration. These well-evidenced practices have been researched, tested, and implemented with a substantial body of scientific evidence supporting their effectiveness in reducing GHG emissions and sequestering carbon. These practices are not mandatory.
Organic fertilisers	Any material that was in its origin wholly or partially a living creature or produced by a living creature such as its waste or its decomposed dead material.
Paludiculture	Growing crops on rewetted peat.
Pasture renovation	A process to improve species composition and extend the productive life of pastures.
Peatland restoration	Actions aimed to restore the original form and function of peatland habitats to favourable conservation status. This typically involves managing the site's hydrology through drain blocking and rewetting in order to raise the water table.
Permanent grassland	Land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for five years or more.
Post-harvest loss	Food loss across the food supply chain from the harvesting of crops until its consumption. In the context of the Taxonomy, this refers to food loss up to the farm gate.
Precision feeding	Feed management that aims to match nutrient supply precisely with the nutrient requirements of individual animals.
Prophylactic	The preventative use of antibiotics. This refers to the treatment of an animal or group of animals before clinical signs of disease.
Pullets	Young hens (less than a year old) that are not yet laying eggs or have only been laying eggs for a short time.

Riparian strips	Riparian strips are permanent bands of vegetation adjacent to watercourses, which provide a physical barrier that helps to slow the flow of water and runoff from fields.
Science Based Targets Initiative's Forest, Land and Agriculture Guidance (SBTi-FLAG)	The Science Based Targets Initiative defines best practice decarbonisation target setting for corporates. The Initiative's FLAG guidance sets a standard for companies in land-intensive sectors to set science-based targets that include land-based emissions reductions and removals.
Scrub	Vegetation consisting primarily of stunted trees and shrubs.
Shelterbelts	A Shelterbelt or windbreak are strips of vegetation composed of trees and shrubs grown along the coast to protect coastal areas and coastal farms from high-velocity winds.
Slurry acidification	The application of acids to slurry to reduce ammonia and methane emissions.
Soil organic carbon (SOC)	Soil carbon is the solid carbon stored in soils. This includes both soil organic matter (SOM) and inorganic carbon.
Soil organic matter (SOM)	Soil organic matter is the organic matter component of soil, consisting of plant and animal matter at various stages of decomposition.
Soil saturation	The threshold at which all of a soil's pores (empty spaces between the solid soil particles) are filled with water. The water content at this threshold varies from 30% in sandy soils to 60% in clay soils.[3]
Space allowance	The amount of floor area given per animal, particularly in the context of individually penned animals.
Stocking density	The number of animals kept in a given unit of area.
The European Food Safety Authority (EFSA)	The European Food Safety Authority provides independent scientific advice on food-related risks. EFSA issues advice on existing and emerging food risks. This advice informs European laws, rules and policymaking.

Upland peat	Primarily ‘blanket bogs’, upland peat is generally thinner than lowland peat and are fed by direct rainfall.
Urease inhibitors	Used in combination with urea fertilisers, delays the conversion of urea to ammonium carbonate which is subsequently converted into N_2O.
Water storage capacity	The total amount of water that is stored in the soil within the plant’s root zone.
Wetland	Areas of marsh, fen, peat, and or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.
Woodland	Land spanning more than 0.5 hectares with trees having the potential to reach a height of at least five metres and a canopy of more than 20%.

2. Commercial wild capture fisheries

2.1. Approach to the fisheries TSC

The TSC for commercial wild capture fisheries have been developed to support the activity's substantial contribution to the protection and restoration of biodiversity and ecosystems. The criteria focus on achieving three environmental outcomes:

1. Sustainable management of fish stocks
2. Minimising bycatch of species
3. Reducing negative impacts on marine habitats.

Recognising that wild capture fisheries involve multiple jurisdictions and transboundary stocks, the TSC also includes a set of minimum baseline practices, aligned with UK legislation, to ensure that the TSC are adaptable to diverse legal and regulatory contexts.

2.2. Commercial wild capture fisheries TSC

Environmental Objective: Biodiversity and Ecosystems

Description: The catching of wild fish and shellfish species from the natural environment that can be sold for commercial profit. The economic activities in this category are associated with the UK SIC code A31.

Context: Recognising the diversity of the UK fishing industry, LNAS recommended TSC for commercial wild capture fisheries to make a substantial contribution to biodiversity and ecosystems and take an environmental outcome-focussed approach rather than prescribing a complete set of management practices that fishers must adhere to in all cases. Individuals, businesses and organisations engaged in the commercial wild capture fishing industry seeking UK Green Taxonomy alignment would be required to demonstrate that their wild capture fish is caught in a way that aligns with the three key environmental outcomes outlined in Tables 2a, 2b and 2c. The catch must also adhere to a minimum set of mandatory requirements and practices that are aligned with domestic and international requirements, to ensure the standards are translatable to other international contexts – these are outlined in Table 1.

How to navigate these criteria for commercial wild capture fisheries	
1. Minimum Baseline	All fisheries must adhere to the minimum baseline requirements outlined in Table 1.
2. Substantial Contribution	A fisher/fishery must demonstrate that the fishing activity aligns with the environmental outcomes described in the following tables. • Table 2a: Outcome 1 - operates in a way that allows fishing to continue indefinitely without over-exploitation of stocks. • Table 2b: Outcome 2 - bycatch is avoided or minimised and population recovery of bycatch species is not hindered. • Table 2c: Outcome 3 - negative impacts on marine habitats are minimised and, where possible, reversed.
3. Demonstrating Compliance	Ways in which a fisher/fishery can demonstrate compliance with the substantial contribution criteria outlined in Table 3.
4. Do No Significant Harm	Fisheries/fishers will then need to comply with the 'Do No Significant Harm' criteria outlined in Table 4.

Table 1: The following is a **minimum set of mandatory baseline practices and requirements** that LNAS members have concluded that a fishery or a fishing operation will need to adhere to, in addition to alignment with the environmental outcomes in Tables 2a, 2b and 2c, to be considered taxonomy aligned. Each technical screening criterion is framed as an environmental outcome and the practices and requirement(s) to achieve that intended outcome. While many of these requirements are already a legal requirement for UK-flagged vessels and vessels operating in UK waters, LNAS members agreed that the TSC need to be adaptable to diverse legal and regulatory contexts, recognising the international and regional dimensions of wild capture fisheries. The inclusion of these mandatory minimum baseline practices and requirements aims to illustrate the level of granularity that the due diligence process should follow to claim that a fishery is taxonomy-aligned, and to ensure these TSC are applicable across different regions and can be translated to other international contexts.

Environmental Outcome	**Table 1: Commercial wild capture fisheries** **Minimum Baseline** for Biodiversity and Ecosystems Substantial Contribution

Non-permitted species, including sensitive species, within the area being fished in are not targeted and are protected	• The target fishery species and wild bait species must not be species which are prohibited for catch or landing under the national legislation of the country where the catch is made or landed.
	• Targeting of species currently identified as endangered or critically endangered by the International Union for Conservation of Nature (IUCN),[298] those listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I[299] and those listed in the Convention on the Conservation of Migratory Species of Wild Animals (CMS), Appendix I,[300] is prohibited. This applies to both targeted species and species used as wild bait.
	  ○ This includes species such as basking shark, oceanic whitetip shark and hawksbill turtle.
	  ○ If the status of a species which may have been assessed as a lower IUCN Red List threat category e.g. vulnerable, is found to be deteriorating then this species should be considered for prohibition.
	• The target fishery species and wild bait species must not be targeted with prohibited methods, such as explosives, under the national legislation of the country where the catch is made or landed.
	• The target fishery species must not be under the minimum conservation reference size (MCRS) under the national or regional legislation of the country where the catch is made or landed.
	• All sharks retained by a fishery must be landed with their fins naturally attached to the body.[301]

	Rationale: This first criterion intends to ensure that sensitive species are not targeted and are protected. The non-permitted species refers to those prohibited by UK national legislation and international listings of endangered species from CITES, CMS and the IUCN. While the CMS Appendix I species duplicates those assessed as "Extinct in the Wild, Critically Endangered, or Endangered" using the IUCN Red List, CMS Appendix I is also included here. This is because, for a species which may have been assessed as in a lower IUCN Red List threat category, which is not part of this minimum baseline (e.g. Near Threatened), special consideration can be made for a CMS Appendix I listing, if its status is deteriorating and the listing would be beneficial for its conservation. LNAS acknowledges that endangered and prohibited species lists are dynamic and therefore recommends this baseline be reviewed, and revised where necessary, every three years in line with the taxonomy TSC revision.

[298] IUCN (2024) International Union for Conservation of Nature (IUCN) red list
[299] CITES (2024) Appendices I, II and III. See Appendix I.
[300] CMS (2020) Appendices I and II of the Convention on the Conservation of Migratory Species of Wild Animals. See Appendix I "Endangered migratory species".
[301] HM Government (2023) UK Shark Fins Act 2023

Bycatch of sensitive species and unwanted fish species is minimised	• Vessels using bottom set gill or entangling nets within at-risk areas of cetacean bycatch must use an acoustic deterrent device commonly referred to as a 'pinger.' • If scientific data indicates a level of incidental catches of seabirds in specific fisheries which constitutes a serious threat to the conservation status of those seabirds, vessels should use bird scaring lines and/or weighted lines. Where practical and beneficial vessels should also set longlines during the hours of darkness with the minimum of deck lighting necessary for safety. • Vessels should use mesh sizes compliant with the national legislation of the country where the catch is made or landed to minimise bycatch of species below MCRS. • If the fisher catches unwanted quota species in the waters of a country with a discard ban, this catch must be landed and counted against quota, unless certain exemptions apply for the species.
	Rationale: While the first criterion ensures sensitive species are not targeted, this criterion recognises that – while not targeted – sensitive species may still be bycaught and LNAS members agreed that measures should be in place to minimise this. The measures provided here are in line with legally binding technical measures, to ensure that: • Incidental catches of marine mammals, seabirds and other non-commercially exploited species do not exceed levels[302] provided through international agreements that are binding on the UK (such as the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas);[303] and • The protection of juvenile marine species from fishing activity (those below Minimum Conservation Reference Sizes (MCRS)) through specific mesh sizes - as authorised by the relevant fisheries administration following scientific assessment and approval. This criterion also recognises that the discarding of unwanted quota species — such as lower value species, undersized species or species not within the fisher's quota — is banned by the UK and the EU, to prevent waste and mortality, reduce unwanted catch (bycatch) and encourage more selective fishing.[304] Some species are exempt from this ban such as basking shark.

[302] ASCOBANS has an intermediary precautionary aim to reduce annual bycatch of small cetaceans to less than 1% of the best available population estimate. See: ASCOBANS (2015) Conservation Objectives and "Unacceptable Interactions"
[303] ASCOBANS (2015) Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
[304] Defra is currently consulting on reforming the discarding rules. See: Defra (2023) Consultation on discards reform

<table>
<tr>
<td rowspan="2">Sensitive habitats are protected - including vulnerable marine ecosystems</td>
<td>

Fishing operations must abide by the national legislation of the country where the catch is made or landed, governing the protection of sensitive habitats, this includes safeguarding vulnerable marine ecosystems (VMEs).[305]

Sensitive habitats and VMEs can include, for example, pink sea fans, deep-sea corals,[306] native oyster reefs, maerl beds[307] and seagrass.
In UK waters, fishing activity must comply with area restrictions to protect sensitive habitats, including VMEs.

Where fishing activity takes place near or within a Marine Protected Area (MPA), such as a Marine Conservation Zone (MCZ), then the activity must be consistent with the national or local legislative requirements to protect that area.

In UK waters, the responsibility for MPAs sits with the relevant devolved authority.[308]

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<tr>
<td>Rationale: While the first two criteria focus on species, this criterion recognises that fishing activity impacts the wider marine ecosystem, and LNAS agrees that measures should be in place to minimise this. The requirements provided here are in line with legally binding measures to protect sensitive areas - including VMEs – from fishing activity.</td>
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<tr>
<td>Relevant catch data is reported and collected</td>
<td>All vessels, including vessels under 10 metres, must report logbook or logbook equivalent catch data, including discards of species taken for live bait purposes, to the relevant national competent authority. This data must be made available for onward supply chain to support full traceability from boat to plate.

In the UK all vessels over 10m in length must maintain and submit a logbook to record activity.[309]
English and Welsh vessels under 10m must submit equivalent logbook data via the CatchApp on completion of landing (for quota species) and within 24 hours for non-quota species.[310]
This data must be verified, either through relevant national competent authorities or an independent third party.

All vessels must report all intentional and incidental mortality and injury of all marine mammals.

In the UK, data should be reported in alignment with vessel licence conditions.[311]

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[305] The United Nations Food and Agriculture Organization (FAO) developed the International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (2009), which set out criteria for the identification of VMEs. See: Walmsley et al. (2021) Vulnerable Marine Ecosystems and Fishery Move-on-Rules, Best Practice Review

[306] ICES (2024) Advice on areas where Vulnerable Marine Ecosystems (VMEs) are known to occur or are likely to occur in EU waters

[307] OSPAR (2008) Case Reports for the OSPAR List of Threatened and/or Declining Species and Habitats: Maerl beds

[308] England 6-200 nautical miles (nm) – Marine Management Organisation; England inshore waters (0-6 nm) – relevant IFCA; Northern Ireland – DAERA; Scotland – Scottish Government; and Wales – Welsh Government

[309] MMO (2014) Fishing data collection, coverage, processing and revisions

[310] MMO (2019) Create and submit catch records for all English and Welsh under 10 metre (U10m) flag vessels that fish in UK waters.

[311] MMO (2021) Marine Mammal Bycatch Reporting Requirements

	Rationale: Fisheries activity data in the UK is reported and collected in line with two main pieces of legislation,[312] which require skippers to keep and submit logbooks and provide landing declarations and sales notes. For 10-metre and under vessels, there is no statutory requirement for fishers to declare their catches, but a licence condition has made this mandatory for all English and Welsh under 10-metre flag vessels that fish in UK waters via a mobile app. LNAS agreed that accurate catch data from all fisheries, including the under 10m, sector is needed to better inform the sustainable management of fisheries. Where methods do not exist for an u10m vessel to record equivalent logbook catch data vessel skippers or owners may use other methods provided by their relevant competent authority such as through weekly landing declarations and sales notes. However, LNAS recommends this ambition level should be revised during the next TSC revision to ensure all vessels under 10m are submitting logbook equivalent catch data. In 2021 a UK vessel licence condition was introduced for all commercial vessels fishing in the UK's Exclusive Economic Zone (EEZ) to report any bycatch of marine mammals within 48 hours of the end of the trip. This was to ensure the continued export of fisheries products to the United States (US) and to comply with international standards for the conservation of marine mammals.[313]
Fishing gear litter is minimised	• In line with legal requirements in the UK,[314] fishing gear must be marked with the port letters and numbers of the fishery's vessel; all lost fishing gear must be retrieved and if unable to so do, the relevant authority must be notified. • If a vessel incidentally recovers discarded gear and litter on board whilst fishing then this must be brought back ashore for correct disposal. • Vessels should also have a plan in place to reduce the risk of lost fishing gear. For example, through gear maintenance, training crew in gear management[315] and utilising flotation buoys[316] and geolocation devices.

[312] Art 14 of Council regulation (EU) No. 1224/2009 requires that all vessels over 10 metres more shall keep a fishing logbook of operations and Art 15 requires that vessels over 12m must submit these electronically. See: HM Government (2009) Council Regulation (EC) NO 1224/2009
[313] MMO (2021) Marine Mammal Bycatch Reporting Requirements
[314] MMO (2016) Marking of fishing gear, retrieval and notification of lost gear
[315] Richardson et al. (2021) Global Causes, Drivers, and Prevention Measures for Lost Fishing Gear
[316] Business Norway (2023) Flotation buoy stops ghost fishing

	Rationale: LNAS recognise that 'abandoned, lost or otherwise discarded fishing gear' (ALDFG) is a problem that is increasingly of concern, as recognised in the 2023 United Nations Environment Programme (UNEP) zero draft treaty on plastics,[317] whereby ALDFG continues to catch fish and other marine animals unselectively.[318] LNAS agrees that at minimum, gear should be traceable, and retrieval attempts should be made if the gear is lost. However, LNAS acknowledges that retrieval may not always be possible, and the taxonomy should incentivise measures to prevent the loss of fishing gear in the first instance.
No illegal, unreported and unregulated fishing	No record of illegal, unreported and unregulated (IUU) fishing activity in the last 5 years, carried out in United Kingdom waters, within maritime waters under the jurisdiction or sovereignty of foreign countries and on the high seas. IUU fishing activity includes the discarding of quota species (with some exemptions), which are legally required to be landed and recorded. IUU fishing is legally defined[319] as below: **Illegal fishing:** • conducted by national or foreign fishing vessels in maritime waters under the jurisdiction of a state, without the permission of that state, or in contravention of its laws and regulations; • conducted by fishing vessels flying the flag of states that are contracting parties to a relevant regional fisheries management organisation, but which operate in contravention of the conservation and management measures adopted by that organisation and by which those states are bound, or of relevant provisions of the applicable international law; or • conducted by fishing vessels in violation of national laws or international obligations, including those undertaken by cooperating states to a relevant regional fisheries management organisation. **Unreported fishing**: • which have not been reported, or have been misreported, to the relevant national authority, in contravention of national laws and regulations; or • which have been undertaken in the area of competence of a relevant regional fisheries management organisation and have not been reported, or have been misreported, in contravention of the reporting procedures of that organisation.

[317] UNEP (2023) Zero draft text of the international legally binding instrument on plastic pollution, including in the marine environment; Part II (9b) "Each Party shall cooperate and take effective measures, including appropriate marking, tracing and reporting requirements, to prevent, reduce and eliminate, abandoned, lost or otherwise discarded fishing gear containing plastic, taking into account internationally agreed rules, standards and recommended practices and procedures"

[318] Do et al. (2023) Ghost fishing gear and their effect on ecosystem services – Identification and knowledge gaps

[319] HM Government (2008) Article 2(2) of (EC) 1005/2008

	Unregulated fishing: • conducted in the area of application of a relevant regional fisheries management organisation by fishing vessels without nationality, by fishing vessels flying the flag of a state not party to that organisation or by any other fishing entity, in a manner that is not consistent with or contravenes the conservation and management measures of that organisation; or conducted in areas or for fish stocks in relation to which there are no applicable conservation or management measures by fishing vessels in a manner that is not consistent with state responsibilities for the conservation of living marine resources under international law.
	Rationale: IUU fishing has a negative influence on fish stocks through overfishing and damage to the marine ecosystem.[320] Fishing is controlled in UK waters with strict regulations such as the registration of buyers and sellers and maintaining a blacklist of vessels engaged in IUU fishing.[321] However, on a wider scale, IUU fishing remains an important global threat to the sustainable management of fish stocks. In recognition of this, a collection of state (including the UK) and non-state actors came together at the UN Ocean in Lisbon 2022[322] and committed to tackling IUU fishing by supporting the IUU Fishing Action Alliance Pledge[323]. Recognising the global scale of IUU fishing, this criterion requires that the vessel has no record of IUU activity in alignment with UK regulations. While fishing is controlled in UK waters, evidence has shown that fish discarding has taken place illegally in UK waters. For example, 2019 analysis using a Freedom of Information (FOI) request of allocated bycatch quota and landing data[324] found that of an estimated 5,200 tonnes allocated to the bycatch of undersize cod by trawlers in the North Sea, 0 tonnes were landed and instead were illegally discarded to use the quota to land adult-sized cod. This analysis and a House of Lords inquiry[325] found similar cases for haddock, whiting and saithe. LNAS agreed that illegal discards warrant being explicitly referred to in the IUU criterion. LNAS recognises that the IUU definition can vary or be misinterpreted - the TSC therefore provides the full legal definition[326] of IUU fishing for clarity.

[320] Seafish (2022) Guide to Illegal, Unreported and Unregulated (IUU) Fishing
[321] (ibid).
[322] UN (2022) Ocean Conference in Lisbon 2022
[323] Defra (2022) IUU Fishing Action Alliance Pledge
[324] OpenSeas (2019) Evidence of continued illegal and unreported fish discarding in West Scotland nephrops trawl fishery
[325] Fishermen 'still illegally discarding dead fish' to a House of Lords inquiry. See: Keane (2019) Fishermen 'still illegally discarding dead fish' says report
[326] HM Government (2008) Art 2(2) of (EC) 1005/2008

Context: The following tables set out the proposed TSC for providing a substantial contribution to the biodiversity and ecosystems, for the activity of 'Commercial Wild Capture fisheries'. The criteria are set out in three tables, with each referring to a different environmental outcome.

Table 2a "Outcome 1": The following is a set of criteria which LNAS members have concluded that a fishery or a fishing operation should adhere to in order to achieve a fishery without over-exploitation of the stock. Each criterion is framed as a contributing environmental outcome – to the main Outcome 1 - and the requirement(s) to achieve that intended outcome. The criteria also consider the health of wild bait stocks, whether caught within the fishery or purchased from elsewhere, to ensure bait comes from healthy stocks.

Environmental Outcome	**Table 2a: Commercial Wild Capture fisheries** **Outcome 1:** Operates in a way that allows fishing to continue indefinitely without over-exploitation of stocks
The fishing level will not lead to an overfished target sock	• There is a high degree of certainty that the target stock has been fluctuating around, or above, a level consistent with Maximum Sustainable Yield (MSY) or an appropriate proxy for MSY, such as biomass or abundance indices. • The fisher or vessel owner operates in a fishery in which the total allowable catch (TAC) of the target stock has a TAC which follows the best available scientific advice to deliver MSY or an appropriate proxy for MSY. ○ The International Council for the Exploration of the Sea (ICES) is the predominant scientific body which advises on the appropriate TACs for commercially managed quota species in the North East Atlantic region.[327] • In cases where MSY or a suitable proxy is unavailable, particularly for data-limited species, the fisher or vessel owner operates in a fishery which has a management strategy with evaluation in place. The management strategy should check the robustness of available reference points, proxies and harvest control rules and implement a road map for the next five years in an adaptive framework to gather information on stock status.
	Rationale: The maximum sustainable yield (MSY) for a given fish stock means the highest possible annual catch that can be sustained over time, by keeping the stock at the level producing maximum growth. The MSY approach has been widely accepted as an objective for fisheries management[328] and in 2020 the UK government introduced a legal objective that stocks are harvested in a way that restores and maintains populations above biomass levels capable of producing MSY.[329] The United Nations Convention on the Law of the Sea (UNCLOS, 1982)[330] notes: "...State(s) must set an allowable catch, based on scientific information, which is designed to maintain or restore species to levels supporting a maximum sustainable yield (MSY)." The constant fishing mortality that

[327] International Council for the Exploration of the Sea (2024) Latest scientific advice for the Azores, Baltic Sea, Barents Sea, Bay of Biscay and Iberian coast, Celtic Seas, Faroes, Greater North Sea, Greenland Sea, Icelandic waters, Norwegian Sea, Oceanic Northeast Atlantic.
[328] WWF (2011) Getting MSY right
[329] HM Government (2020) UK Fisheries Act 2020 Section 1(3)
[330] UNCLOS (1982) United Nations Convention on the Law of the Sea (UNCLOS)

	gives this MSY is F_{MSY}, where F is the fishing mortality rate. The stable population size is B_{MSY} (= "biomass MSY"). Reaching MSY means implementing a management policy that rebuilds the stock to the B_{MSY} level within a chosen time frame. This is typically done by managing fishing mortality over a multiannual period — by setting total allowable catch (TAC) or effort limits — until the stock biomass rebuilds to B_{MSY} and, consequently, annual catch and fishing mortality reach MSY and F_{MSY}, respectively.[331] Each year the International Council for the Exploration of the Sea (ICES) provides independent scientific advice for TAC-setting in the North East (NE) Atlantic region, inclusive of UK waters. For each stock, ICES provides advice based on delivering the MSY where there is enough information.[332] However, MSY assessments require a data-rich approach which limits the number of stocks that can be assessed on this basis, ICES therefore also provides advice for data-limited stocks which is based on the precautionary approach.[333] For example, for the data-limited black scabbardfish in the Northeast Atlantic ICES uses an abundance index to determine catch advice.[334] Recognising this, LNAS agreed that the criteria should allow for the use of suitable proxies alongside MSY, such as abundance indices. LNAS agreed that while ICES provides the source of best available science and should be followed as best practice their advice is not, or cannot, always be followed. UK government data highlights that, while in recent years progress has been made in aligning TACs with scientific advice, only 46% of baseline TACs (which were set through negotiations) were consistent with ICES advice in 2024.[335] TACs which did not follow scientific advice include West of Scotland cod,[336] Celtic Sea cod[337] and Irish Cod[338] – where ICES has continued to advise zero catch on the basis that "there are no catch scenarios that will rebuild the stock above B_{lim}" [a very low level of biomass that indicates a high risk of stock collapse]. UK government data is not provided for unilaterally set TACs. However, unilaterally set quotas for mackerel, herring and blue whiting in the NE Atlantic have consistently amounted to TACs substantially higher than the scientific advice.[339] Failing to adhere to the advised catches "may result in an increased risk for the stock to fall below B_{lim}, of catch in the long term and unsustainable utilization of the resource."[340] LNAS agreed that the goal should be to maximise the alignment of TACs with scientific advice to recover and maintain healthy stocks.

[331] WWF (2011) Getting MSY right
[332] ICES (2022) technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3
[333] ICES (2012) Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice
[334] ICES Advice on fishing opportunities, catch, and effort (2016): Black scabbardfish in the Northeast Atlantic
[335] Cefas (2024) Assessing the sustainability of fisheries catch limits negotiated by the UK for 2024
[336] ICES (2022) Advice on fishing opportunities, catch, and effort for 2023 and 2024, West of Scotland cod
[337] ICES (2022) Advice on fishing opportunities, catch, and effort for 2023, Celtic Sea cod
[338] ICES (2022) Advice on fishing opportunities, catch, and effort for 2023, Irish Sea cod
[339] Marine Stewardship Council (2023) Northeast Atlantic Pelagic Fisheries – Management Challenges for Straddling Fish Stock
[340] (ibid). Table 2. Summary of stock status, source ICES

	While LNAS members recognise the complexity of international negotiations and the socio-economic factors at play, LNAS members strongly agreed that catching more than the scientific advice cannot be done without risking stock collapse and therefore cannot be labelled as environmentally sustainable. For significantly data-poor species such as non-quota species (NQS) then the fisher or vessel owner must operate in a fishery that has a management strategy implemented that includes plans for additional data collection in order to establish MSY values.
Sourcing of wild bait is environmentally sustainable	• If the wild bait is sourced from a commercial fishery, within the fishery or purchased from elsewhere, then that fishery must also be aligned with this taxonomy criteria. • Bait can be sourced from fish that cannot otherwise be landed in a fishery – such as landed undersized quota fish – provided that the value of such fish is handled by an independent third party, to prevent the fisher from drawing from commercial profit from such fish. • The bait cannot comprise of any illegal components and be subject to periodic checks and verification.
	Rationale • LNAS agreed that wild-caught bait, whether caught within the fishery or purchased from elsewhere, needs to be considered because all aspects of the fishery need to be sustainable to be taxonomy-aligned, including those relating to the stocks of the bait species. This is also in alignment with the requirements for a fishery to become certified against the Marine Stewardship Council sustainable fisheries standard.[341] Certain national laws require discards of quota species to be landed, this criterion allows for the recycling of those discards (to prevent waste) in bait.[342] While certain national laws allow the sale of those discards, provided that it is reported, counted against quota and not sold for human consumption, LNAS members agreed that a green taxonomy should incentivise practices that avoid bycatch. As such, the criterion requires that the fisher draws no commercial profit to prevent green-aligned fisheries from profiting from bycatch.

[341] MSC (2022) Fisheries Standard 3.1
[342] Defra, NFFO and Seafish (2014) Fishing for the Markets: Use of discards in bait

Table 2b "Outcome 2:" The following is a set of criteria which LNAS members have concluded that a fishery or a fishing operation should adhere to in order to achieve avoidance or minimisation of bycatch, and not hinder population recovery of bycatch species. Each criterion is framed as a contributing environmental outcome – to achieve main Outcome 2 - and the requirement(s) to achieve that intended outcome. The criteria cover monitoring of discards and bycatch, along with best practice for minimising and where possible eliminating incidental catches of unwanted fish species, marine mammals, seabirds and elasmobranchs.

Environmental Outcome	**Table 2b: Commercial Wild Capture fisheries** **Outcome 2:** Bycatch is avoided or minimised and population recovery of bycatch species is not hindered
Sufficient levels of bycatch monitoring for marine mammals, seabirds and elasmobranchs and discarding of unwanted fish species	Vessels over 10m must monitor bycatch of sensitive marine species (cetaceans, seals, seabirds and elasmobranchs),[343] and discards of fish species, using onboard observers and/or Remote Electronic Monitoring (REM) systems or other wider monitoring technologies such as passive acoustic monitoring, low-altitude satellites and AI technology. A sufficient percentage rate of video data should be reviewed by either the relevant national authority or an accredited third-party to fill in existing data gaps for injury, mortality, and discarding in UK waters. This rate should be set through a risk-based approach which takes into account the gear group and area of operation. • For example, a higher review rate could be set for active bottom-contacting gear groups, such as otter trawls, which are shown to be the most detrimental compared to other gear types in terms of total amounts of unwanted catches and discards.[344]
	Rationale: LNAS members agreed that the monitoring and reporting of bycatch of sensitive species and unwanted fish species is needed to ensure that fisheries are managed sustainably. It is challenging to determine the exact number of sensitive marine species affected by bycatch or entanglement due to high levels of uncertainty in estimates, which is driven by low observer and electronic monitoring coverage at sea, combined with low sampling effort.[345][346] For example, the UK BMP relies on onboard observation – coverage currently sits at <1% of annual static net effort, 1-2% of annual longline effort and roughly 5% of annual midwater trawl effort, and only on UK flagged vessels – and, since 2021, self-reporting of bycaught marine mammals (this does not include the

343 Elasmobranchs include sharks, skates, rays, guitarfishes and chimaeras.
344 Roda et al. (2019) A third assessment of global marine fisheries discards
345 Defra (2022) Marine wildlife bycatch mitigation initiative
346 Good et al. (2020) National Plans of Action (NPOAs) for reducing seabird bycatch: Developing best practice for assessing and managing fisheries impacts

	requirement to report seabirds and elasmobranchs). Coverage and underreporting[347] have been shown to be insufficient for providing the level of data required to obtain accurate mortality estimates in UK waters.[348][349][350][351] While estimates vary, a 2021 report commissioned by Humane Society International and Whale and Dolphin Conservation (WDC) indicates over 1000 cetaceans a year are bycaught in UK waters,[352] the BMP estimated that between 502 to 1,560 harbour porpoises, 165 to 662 common dolphins, 375 to 872 and seals (grey and harbour) were captured as bycatch in UK fisheries in 2019.[353] For seabirds, the BMP estimates that bycatch from UK vessels in longline, gillnet and midwater trawl fisheries account for 2,200-9,100 fulmar and 1,800-3,300 guillemot mortalities each year.[354] For elasmobranchs, the UK government acknowledges that mortality and morbidity numbers are much harder to quantify but estimates that numbers are much higher than marine mammals or seabirds.[355] In addition, the discarding of fish bycatch can take place for many reasons, including high-grading, the capture of fish which are below legal minimum conservation reference size (MCRS), or the fish that is of low economic value, or poor marketable quality. The FAO (2019) has estimated annual amounts of discards of around 1.5 million tonnes of discards in the North-East Atlantic, and 250 thousand tonnes in the Mediterranean and Black Sea - attributed to the large amount of catch from bottom-trawl fisheries, which have been found to have the highest discard rates amongst all gear types.[356] However, as with bycatch of sensitive species, it is difficult to determine the true weight of discards which takes place owed to small sample sizes of records of observed discard rates and low levels of observer coverage.[357] LNAS discussed and agreed that reliable estimates of discards are essential to better inform sustainable fisheries management. **Role of REM in addressing data gaps** Remote electronic monitoring (REM) systems coupled with CCTV have emerged as an alternative method that could complement traditional monitoring programmes. REM can independently collect data, without relying on self-reporting, of sensitive marine species

[347] EFRA (2023) Committee Marine Mammals Inquiry - additional information
[348] Northridge et al. (2020) Research and Development for the UK Seabird Plan of Action
[349] Environment, Food and Rural Affairs Committee (2023) Protecting Marine Mammals in the UK and Abroad
[350] Defra (2022) Marine wildlife bycatch mitigation initiative
[351] Course (2021) Monitoring Cetacean Bycatch: An Analysis of Different Methods Aboard Commercial Fishing Vessels
[352] Leaper (2021) An Evaluation of Cetacean Bycatch in UK Fisheries: Problems and Solutions
[353] Defra (2017) UK Bycatch Monitoring Programme: Cetacean Bycatch Observer Monitoring System
[354] Northridge et al. (2020) Defra commission - Research and Development for the UK Seabird Plan of Action
[355] Defra (2022) Marine wildlife bycatch mitigation initiative
[356] Roda et al. (2019) A third assessment of global marine fisheries discards
[357] Gilman et al. (2020) Benchmarking global fisheries discards

	bycatch and fish discards, allowing for later verification and a better understanding of interactions with different gear types.[358][359] Successful trials have demonstrated REM's effectiveness, for example, in 2015 discards of cod by vessels participating in the North Sea REM pilot scheme were well below 1% of the catch, compared to 41% for non-participating vessels.[360] Volunteers within five government-identified priority fisheries will begin to use REM systems in English waters[361] and the Scottish government has introduced legislation for mandatory REM on all scallop dredgers and pelagic vessels (including freezers) fishing in Scottish waters, following successful trials, while further rollout of REM beyond these fleet segments is being planned.[362] LNAS members recognise that REM alone will not eliminate bycatch or discarding issues, but it can provide a significantly improved data set to build a comprehensive picture of fleet activities, gear interactions and the extent of bycatch and discarding events. This data is necessary to inform management strategies and implement targeted mitigation measures. **Risk-based approach to data review** LNAS recommends that 100% of REM data be collected but that a percentage rate of data review be set according to a risk-based approach. This rate should be sufficient to fill in the data gaps in observer coverage.[363] Higher review rates could apply to gear types and areas associated with higher bycatch or discard risks, such as active bottom-contacting gear (e.g. otter trawls), where high levels of unwanted catches and discards are known to occur.[364] This data could be reviewed either by a national authority or an accredited third party. While LNAS recognises that the use of REM in many contexts is under government management or subject to various trials and proposals, these recommendations are based on LNAS's independent advice of the best available practices to achieve environmentally sustainable fisheries management in line with a green taxonomy. REM provides the best available solution to address data gaps to provide a comprehensive picture of fishing activity and, through seeking alignment, green finance can support investment into REM technology.

[358] Course (2021) Monitoring Cetacean Bycatch: An Analysis of Different Methods Aboard Commercial Fishing Vessels
[359] Environment, Food and Rural Affairs Committee (2023) Protecting Marine Mammals in the UK and Abroad
[360] MMO (2017) Fully Documented Fishery scheme helping to reduce discards of quota species
[361] Defra and Spencer (2024) UK fishing industry to benefit from cutting-edge technology to help manage fish stocks
[362] GOV.SCOT (2024) Remote electronic monitoring (REM)
[363] Course (2021) Monitoring Cetacean Bycatch: An Analysis of Different Methods Aboard Commercial Fishing Vessels
[364] Roda et al. (2019) A third assessment of global marine fisheries discards

	LNAS also recognises that mandatory reporting requirement would be a greater burden on smaller vessels, which only land 6% of the total UK fleet catch by weight[365] and therefore recommends REM would only apply to the over 10m. LNAS recommends this ambition level should be revised, based on a risk assessment to identify additional requirements for the under 10m fleet, during the next TSC review period.
Incidental catches of marine mammals, seabirds, elasmobranchs and unwanted fish species are minimised and where possible eliminated	• Evidence that the fishing activity follows best available practices to minimise and where possible eliminate bycatch of sensitive and unwanted fish species: ○ **Best practice for reducing direct interactions,** for example: ▪ Avoiding bycatch hotspots of sensitive species and using real-time bycatch detection technologies that alert fishers to the presence of cetaceans and share real-time information about the location of hotspots of fish species that are choke species.[366] ▪ Gear modification: implementing line-weighting and bird-scaring lines for demersal long-line gears to reduce seabird mortality, use of pingers as a deterrent for cetaceans, excluder devices and removing tickler chains in benthic trawls to minimise bycatch of sharks and rays. ▪ Increasing the selectivity of fishing gear: for example using square, rather than diamond, codends and larger mesh panels in trawls to give fish a longer time to escape and sorting grids to separate unwanted fish species before they enter trawls. ▪ Gear switching toward more selective gear: for example using longlines instead of gillnets where possible. ○ **Best practice for reducing mortality when interactions occur,** which can include crew training programmes on the safe handling and release of bycatch, releasing elasmobranchs from the purse seine net at sea, rather than after being brought on board and only releasing birds if they are uninjured and mostly dry. • Resources available to help implement best practices include: ○ Convention on the Conservation of Migratory Species of Wild Animals (CMS): **"Guidelines for the Safe and Humane Handling and Release of Bycaught Small Cetaceans from Fishing Gear"**[367]

[365] WWF-UK (2017) Remote Electronic Monitoring in UK Fisheries Management
[366] BATmap, or By-catch Avoidance Tool using mapping, is an app for Scottish skippers to share real-time information about the location of hotspots of fish species that are choke species (cod) or of conservation interest (spurdog) with other participating skippers.
[367] CMS (2020) Guidelines for the Safe and Humane Handling and Release of Bycaught Small Cetaceans from Fishing Gear

	○ Seafood Business for Ocean Stewardship (SeaBos): **"Best practices for reducing negative impacts on endangered elasmobranchs and seabirds"[368]** ○ Food and Agricultural Organization (FAO): **"Guidelines to prevent and reduce bycatch of marine mammals in capture fisheries"[369]** ○ Agreement on the Conservation of Albatrosses and Petrels (ACAP): **"Mitigation measures and best practice advice for reducing the impact of demersal longline fisheries on seabirds"[370]** ○ Agreement on the Conservation of Albatrosses and Petrels (ACAP): **"Mitigation measures and best practice advice for reducing the impact of reducing the impact of pelagic and demersal trawl fisheries on seabirds"[371]** ○ International Whaling Commission (IWC): **"Principles and guidelines for large whale entanglement response efforts"[372]** ○ FAO: **"International Guidelines on Bycatch Management and Reduction of Discards"[373]**
	Rationale: LNAS recognises that the fishing fleet is diverse and not a one-size-fits-all approach should be prescribed to fishers. Instead, the criteria provide example practices that fishers could adopt to minimise and where possible eliminate bycatch, based on internationally recognised standards and approaches. LNAS members agree that following best practice to minimise or eliminate bycatch, can support achieving population-based outcomes (e.g. ensuring recovery to at least 50% of carrying capacity) for sensitive species with conservation thresholds.[374] • **Cetaceans and seals** ○ Gillnets are considered the riskiest gear to most species. Gear-switching trials have shown, for example, comparable catch levels (and reduced seal interactions) by switching gillnets with longlines for Baltic Sea Cod.[375] While removing vertical lines from the water column is considered one of the most effective ways to ensure that large whales do not become entangled in them - the New South Wales rock lobster pot fishery in Australia has used bottom-stowed vertical lines for more than a decade.[376] ○ Acoustic alerting or deterrent devices (primarily pingers) can alert cetaceans to the presence of a net or drive them away from its location, serving as an effective bycatch mitigation method.

[368] SeaBos (2021) Best practices for reducing negative impacts on endangered elasmobranchs and seabirds
[369] FAO (2021) Guidelines to prevent and reduce bycatch of marine mammals in capture fisheries
[370] ACAP (2023) Mitigation measures and best practice advice for reducing the impact of demersal longline fisheries on seabirds
[371] ACAP (2023) Mitigation measures and best practice advice for reducing the impact of pelagic and demersal trawl fisheries on seabirds
[372] IWCN (2018) Principles and guidelines for large whale entanglement response efforts
[373] FAO (2011) International Guidelines on Bycatch Management and Reduction of Discards
[374] ASCOBANS has an intermediary precautionary aim to reduce the annual bycatch of small cetaceans to less than 1% of the best available population estimate. See ASCOBANS (2015) ASCOBANS Conservation Objectives and "Unacceptable Interactions"
[375] (ibid).
[376] (ibid).

	○ Some promising AI technology to prevent marine bycatch include AI-empowered fishing nets to determine the individual size and species of marine life captured inside a trawl net using images taken by an underwater stereo camera. It then releases or retains each marine animal depending on whether it qualifies against a trawler's intended catch using a computer-controlled robotic gate.[377] • **Sea birds** ○ Line weighting is one of the most proven mitigation measures in demersal longline fleets.[378] Studies have shown that implementing line weighting, where there is more mass closer to the hooks, results in hooks sinking most rapidly and consistently reduces bird attacks on bait and seabird mortality.[379][380][381] ○ Bird-scaring lines (also known as tori lines) are designed to provide a physical deterrent over the area where baited hooks are sinking and there have been extremely effective extensive trials of this method in a range of fleets worldwide.[382][383] • **Elasmobranchs** ○ Responsible handling (and avoidance of traumatic handling practice) of rays after capture significantly reduces rates of post-release mortality.[384][385] ○ One way to effectively reduce bycatch mortality of sharks in longlines is to reduce the soak time (the time that longlines are in the water). Elasmobranchs removed more quickly from longlines have a higher chance of survival since their breathing depends on the capacity to continue swimming.[386]

[377] Heriot Watt University (2023) AI-empowered fishing net to help prevent marine bycatch
[378] Anderson et al. (2017) Seabird bycatch mitigation: evidence base for possible UK application and research
[379] Santos et al. (2019) Improved line weighting reduces seabird bycatch without affecting fish catch in the Brazilian pelagic longline fishery
[380] Jiménez et al. (2018) Mitigating bycatch of threatened seabirds: the effectiveness of branch line weighting in pelagic longline fisheries
[381] Barrington et al. (2016) Categorising branch line weighting for pelagic longline fishing according to sink rates.
[382] Anderson et al. (2017) Seabird bycatch mitigation: evidence base for possible UK application and research
[383] Clarke (2014) Bycatch in Longline Fisheries for Tuna and Tuna-like Species: a Global Review of Status and Mitigation Measures
[384] Carlson et al. (2020) Safe handling and release guidelines for manta and devil rays (mobulid species).
[385] Wosnick et al. (2023) An overview on elasmobranch release as a bycatch mitigation strategy
[386] Carruthers et al. (2011) Overlooked bycatch mitigation opportunities in pelagic longline fisheries: Soak time and temperature effects on swordfish and blue shark

	• **Unwanted fish species** ○ Changes in fishing gear design and operation have long been employed by fishers to minimise the capture of undersized fish or unwanted species.[387][388] Gear modifications include changes in the size and shape of mesh and hook, longlines leader material, escape panels in traps, acoustic alarms, biodegradable panels, square mesh panels, underwater lights and sorting grids.[389] ○ Typically, active bottom-contacting gear groups are less selective than other gear types and thus have a higher risk for bycatch of unwanted species. Therefore, modifications should be made to increase the selectivity of these gear types, such as through changing the shape and increasing the size of mesh in trawls to allow easier escape of fish,[390] and sorting grids to allow smaller creatures, like shrimp, to pass through a grid to reach the net proper while bigger species, like cod, are directed towards an escape hole.[391]

[387] Madhu et al. (2023) Square mesh codend improves size selectivity and catch pattern for Trichiurus lepturus in bottom trawl used along Northwest coast of India
[388] Roda et al. (2019) A third assessment of global marine fisheries discards
[389](ibid).
[390] O'Neill et al. (2018) Discard Avoidance by Improving Fishing Gear Selectivity: Helping the Fishing Industry Help Itself
[391] WWF (2007) Discards position statement

Table 2c "Outcome 3": LNAS experts agree that any fishery that is seeking to be sustainable must consider the broader ecological functions of the environment in which it operates. The following criteria, which LNAS members have discussed and agreed upon, adopt an ecosystem-based approach to minimise and, where feasible, reverse the adverse effects of fishing activity on marine ecosystems.

Table 2c: Commercial wild capture fisheries **Outcome 3:** Negative impacts on marine habitats are minimised and, where possible, reversed.	
Impact on seabed habitats is minimised to avoid disturbance and mortality of benthic biota and disturbance/disruption of the biogeochemical integrity of the seabed	**Minimise impact on seabed habitats to avoid disturbance and mortality of benthic biota:** • **Prohibited areas:** Fishing activity that disturbs benthic biota should not take place in ecologically important seabed habitats, such as kelp forests, Marine Protected Areas (MPAs) in areas of high abundance or functionally diverse benthos, deep-sea sponge gardens and oyster beds. Ecologically important seabed habitats include those which have been designated under the national legislation of the country where the catch is made or landed, such as through the UK's network of MPAs,[392] and through multi-environmental treaties such as those listed under the OSPAR List of Threatened and/or Declining Species and Habitats.[393] • **Bottom fishing in resilient areas:** Fishing activity that disturbs benthic biota should be limited to more resilient areas, whereby fishing rates can be sustained if the habitat, community or process recovers quickly from fishing activity. Communities found in unconsolidated mobile sediments are expected to be better adapted to natural disturbance than those found in consolidated sediment and hard-bottom areas.[394] • **Lessening the impact where bottom contact occurs:** Fishing operations that disturb benthic biota should utilise gear types and gear modifications that minimise impact on the seabed while maintaining an acceptable level of performance. These include modifications to reduce physical contact and penetration depth of gear within the seabed or that limit the weight of the gear. For example gear modification that lifts steel bags used for scallop dredging and lighter/high-aspect-ratio/manoeuvrable semi-pelagic trawl doors that reduce the contact area of otter trawls.[395]

[392] JNCC (2020) UK MPA network
[393] OSPAR (2024) OSPAR List of Threatened and/or Declining Species and Habitats
[394] Lambert et al. (2014) Quantifying recovery rates and resilience of seabed habitats impacted by bottom fishing
[395] McConnaughey et al. (2019) Choosing best practices for managing impacts of trawl fishing on seabed habitats and biota

	Rationale: Mobile bottom fishing, such as trawling, dredging, raking and suction fishing methods, is the most widespread direct human impact on marine benthic systems.[396] This can directly and indirectly impact populations and communities of benthic invertebrates, with significant reductions in abundance, biomass, species diversity, body size and productivity reported in many studies.[397][398][399][400] Studies have also shown that the recovery of sea beds and ecosystems from scallop dredging can take up to ten years.[401] Further still one study found that, on average, 70% of coral-like maerl is removed from an area by a single dredge tow and it takes many decades for the maerl to recover.[402] An Ecosystem-Based Approach to fisheries takes account of the interaction between exploited species and their ecosystem. These criteria, therefore, aim to minimise the impact on the wider marine ecosystem through a three-pronged approach: 1. **Prohibited areas:** prohibiting activity in habitat types that are both easily disturbed and slow to recover, such as seagrasses, sponges, corals and other endemic or rare types of seabed communities.[403] MPAs in areas of high benthos abundance and diversity, which prohibit trawling, or include zones that are closed to trawling, can improve benthic ecosystems while enhancing fish production through export and spillover of juveniles and adults from MPAs into adjacent fisheries.[404] One study found that rocky reefs in Scotland see scallop dredging hold 30% less fauna than rocky reefs in areas where scallop dredging is banned.[405] 2. **Bottom fishing in resilient areas:** Recognising that not all habitats are easily disturbed and slow to recover, this allows for bottom fishing to occur if the environment is resilient and with fast recovery rates. The resilience of a habitat, community or process to fishing impacts can be measured as the inverse of the recovery time following a defined impact.[406] High tidal energy areas with coarse sediment and hard-bottomed habitats, for example, are found to have high recovery rates.[407] 3. **Lessening the impact where bottom contact occurs:** A number of gear modifications will reduce the direct impacts of bottom trawling on benthos by reducing physical contact and penetration depth of gear within the seabed. For example, large-diameter rubber bobbins separated by rows of small-diameter discs create openings under the footrope that reduce

[396] Hughes et al. (2014) Investigating the effects of mobile bottom fishing on benthic biota: a systematic review protocol
[397] Collie et al. (2017) Indirect effects of bottom fishing on the productivity of marine fish.
[398] Collie et al. (2000) A quantitative analysis of fishing impacts on shelf-sea benthos.
[399] Hiddink et al. (2017) Global analysis of depletion and recovery of seabed biota after bottom trawling disturbance.
[400] Sciberras et al. (2018) Response of benthic fauna to experimental bottom fishing: A global meta-analysis.
[401] Lambert at al. (2014) Quantifying recovery rates and resilience of seabed habitats impacted by bottom fishing
[402] Spencer and Moore (2000) Scallop dredging has profound, long-term impacts on maerl habitats
[403] McConnaughey et al. (2019) Choosing best practices for managing impacts of trawl fishing on seabed habitats and biota
[404] (ibid).
[405] Boulcott et al (2014) Impact of scallop dredging on benthic epifauna in a mixed-substrate habitat
[406] Hiddink et al. (2007) Assessing and predicting the relative ecological costs of disturbance to habitats with different sensitivities.
[407] Lambert et al. (2014) Quantifying recovery rates and resilience of seabed habitats impacted by bottom fishing

	the unobserved mortality of commercially valuable crab species. For fly-wires attached to the warps (fork-rigged trawl), shortening the warp-length-to-depth ratio and lighter/high-aspect-ratio/manoeuvrable semi-pelagic trawl doors also reduce the contact area of otter trawls.[408] LNAS members agree that through seeking alignment, green finance can support switching to more environmentally sustainable methods – e.g. lights, combined with specially modified pots, have been shown to effectively catch scallops in a low-impact way (compared to scallop dredging)[409] and to modify gear to reduce the direct impacts of bottom fishing methods.

Table 3: Commercial Wild Capture fisheries Ways in which a fisher/fishery can demonstrate compliance with the Substantial Contribution TSC
For TSC which specify verification, external verifiers can be either the relevant national competent authorities or an independent third-party verifier; having no conflict of interest with the operator of the activity or being involved in the development or operation of the activity. Standards which satisfy these criteria: 1. The target stock has a verified unconditional pass against the MSC standard 3.0.[410] 2. The target stock is verified against an independent standard that complies with the UN FAO Best Practice Guidelines for Ecolabelling.[411]

Table 4 "Do No Significant Harm (DNSH)" Do No Significant Harm is the second of the tests that an activity must show it meets in order to be deemed taxonomy-aligned. The below DNSH criteria will set out how a fishing activity does not significantly harm any of the other five environmental objectives while making a substantial contribution to biodiversity and ecosystems. Wild capture fisheries can have wider environmental impacts outside of biodiversity that need to be considered for investments in the sector. Based on that understanding, LNAS suggests the DNSH criteria could include the below list of potential impacts against the other five environmental objectives:

[408] McConnaughey et al. (2019) Choosing best practices for managing impacts of trawl fishing on seabed habitats and biota
[409] Duffy (2022) UK marine scientists discover breakthrough for a low impact scallop fishery
[410] MSC (2022) Fisheries Standard v3.0
[411] FAO (2009) Guidelines for the ecolabelling of fish and fishery products from marine capture fisheries

- **Climate change adaptation:** the ability of fisheries to adapt to climate change and for fishing activity to adapt to shifts in marine species' distributions
- **Climate change mitigation:** protecting carbon rich marine habitats, phasing down F-gases and moving towards less diesel-intensive vessels
- **Transition to a circular economy:** traceable and reusable fishing gear at the end of life
- **Pollution prevention and control:** no bilge dumping, best practice to prevent diesel spills and reducing noise pollution
- **Sustainable use and protection of water:** not hindering good environmental status of marine waters

It should be noted that GTAG set out a series of recommendations to the UK government on how to approach the development of DNSH criteria in the UK Green Taxonomy, in its August 2023 paper on this topic.[412] There have been usability issues observed in DNSH criteria in other jurisdictions to date, which include issues due to the drafting of the criteria themselves, and GTAG provided advice on potential ways to fix these issues. Therefore LNAS recommends that the DNSH criteria for commercial wild capture fisheries be fully developed once the UK government has clarified its approach to DNSH in the UK Green Taxonomy. As such, this table sets out guidance as to what LNAS considers the primary issues that the final DNSH criteria for commercial wild capture fisheries should address, but LNAS has not proposed the final wording for the criteria at this stage, pending the UK government's clarification of its way forward on DNSH.

Table 4: Do No Significant Harm (DNSH) Criteria	

Climate Change Adaptation	• LNAS recommends that the UK government develop the DNSH criteria for climate change adaptation once the UK government has clarified its approach to adaptation and DNSH in the UK Green Taxonomy. LNAS members have provided primary issues to consider when developing adaptation DNSH criteria.
	• Fishing activity will need to adapt to migrating stocks, as more southern species migrate north, at a faster rate, as waters warm.
	  ○ Climate-related changes in UK seas have been especially marked by a warming trend. The general pattern for future change is the further replacement of cold-water species (e.g. Atlantic Cod and cold-water kelp species) with warmwater species (e.g. Northern hake and striped dolphins).[413]
	  ○ National and international TAC and quota systems will need to adapt to the northward movement of certain species to acknowledge the revised zonal attachment of those species.

[412] GFI, GTAG (2023) Streamlining and increasing the usability of the Do No Significant Harm (DNSH) criteria within the UK Green Taxonomy
[413] CCC (2017) UK Climate Change Risk Assessment 2017 Evidence Report: Technical chapters: Natural environment and assets

	• Ocean acidification also impacts plankton productivity, which fuels marine food webs, creating complex and dynamic interactions with fisheries productivity.[414] • LNAS members agreed that fishing activity, therefore, such as government quota allocation and traditional catch areas, will need to change to ensure no harm is caused to dynamic stock behaviour. For example, ensuring fishing effort does not target migrating spawning grounds.

Climate Change Mitigation	**Carbon-rich habitats:**
	• The fishing activity should not unduly disturb or disrupt carbon rich sediments.
	  ○ The ongoing Convex Seascape Survey project[415] is producing open-source data on continental shelf carbon.
	
	For vessels with freezing/refrigeration facilities on board:
	• Phase out of CFCs and HCFCs in compliance with the Montreal[416] and Kigali Protocols,
	• Phase down HFCs in compliance with the Montreal Protocol including its Kigali amendment on HFCs,[417]
	• Where processing onboard, compliance with the F-gas Regulation (EU) No 517/2014: banning the use of Fluorinated GHGs (F-gases) including hydrofluorocarbons (HFCs).[418]
	
	For fishing vessels using marine diesel
	• LNAS agreed that the DNSH criteria should incentivise the move towards less diesel-intensive vessels, of which investment will be key, with a possible split by vessel size:
	  ○ Smaller vessels moving towards electrification and larger vessels moving towards hybrid technologies and becoming more fuel efficient.
	
	Fish as a carbon stock
	• In line with outcome 1 (Table 2a), catch limits should follow scientific advice to recover and maintain stocks at sustainable levels to keep more fish biomass in the sea – as a natural source of carbon sequestration.[419]

[414] Stock et al. (2017) Reconciling fisheries catch and ocean productivity
[415] Blue Marine Foundation (2023) Convex Seascape Survey
[416] UNEP (n.d.) Phase out of HCFCs – the Montreal Amendment
[417] UNEP (2016) Annex I: Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (2016)
[418] HM Government (2014) Regulation (EU) No 517/2014 on fluorinated greenhouse gases
[419] Over the past five decades, commercial fishing extracted 318.4 million metric tons of large fish from the ocean, causing approximately 37.5 million metric tons of carbon to be released into the atmosphere. Of that amount, at least 21.8 million metric tons of carbon would have been naturally sequestered through the bodies of those fish sinking to the bottom of the ocean had they not been removed from the sea. See: Mariani et al. (2020) Let more big fish sink: Fisheries prevent blue carbon sequestration – half in unprofitable area

Transition to a circular economy	• Fishing gear should be reused or recycled at the end of life. • The use of virgin plastics for fishing should be phased down/minimised and move towards recyclable or biodegradable/non-polymer/non-fossil fuel-based fishing gear and rope materials. • All fishing gear should be labelled and traceable in line with international guidelines.[420]
Pollution prevention and control	• LNAS members agreed that the DNSH criteria should prevent bilge water dumping and incentivise best practice to prevent diesel spills and to reduce noise pollution. • LNAS agreed with tying the Good Environmental Status (GES) targets[421] into this, as this provides quantifiable outcomes. For example: ○ The fishing activity does not cause litter on coastlines and in the marine environment which poses a significant risk to the coastal and marine environment.[422]
Sustainable use and protection of water	• LNAS agreed that there is overlap between water use and pollution prevention and suggested that this objective should either pertain to the sustainable use of freshwater only OR the pollution prevention becomes a subsidiary of the sustainable use and protection of marine water.

420 FAO (2019) Voluntary Guidelines on the Marking of Fishing Gear
421 Cefas (2018) Summary of progress towards Good Environmental Status
422 Cefas (2018) Assessment of progress towards the achievement of Good Environmental Status for marine litter.

2.3. Fisheries technical glossary

Abandoned, Lost or otherwise Discarded Fishing Gear (ALDFG)
"Abandoned fishing gear" refers to fishing gear over which that operator/owner has control and that could be retrieved by the owner/operator but is deliberately left at sea due to force majeure or other unforeseen reasons. "Lost fishing gear" refers to fishing gear over which the owner/operator has accidentally lost control and that cannot be located and/or retrieved by the owner/operator. "Discarded fishing gear" refers to fishing gear that is released at sea without any attempt for further control or recovery by the owner/operator.

B_{lim}
Limit reference point for spawning stock biomass (SSB). A stock with biomass below Blim is at greater risk of suffering impaired recruitment.

B_{MSY}
B_{MSY} is the limit biomass reference point, below which the fish stock has reduced reproductive capacity and an increased risk of stock collapse.

Bycatch
Bycatch can refer to the unintentional catch of other commercial species that are landed, commercial species that cannot be landed (e.g. undersized, damaged individuals), non-commercial species as well as to the incidental catch of endangered, vulnerable, or rare species (e.g. sea turtles, sharks, marine mammals).

Demersal species
Demersal refers to fish species living near or on the sea floor.

Discards and high grading
Discarding is the practice of returning unwanted catches to the sea, either dead or alive. High-grading is the practice of discarding low-value catches of any species that can be legally landed in order to preserve the quota for higher-value fish.

Disturbance of benthic biota
Actions that upset the normal state of the benthic biota. Changes that modify habitats and reduce biodiversity and productivity through their effects on a range of species, including those that provide biogenic structure (e.g., sponges, tubeworms, anemones), or modify the sediment.[5]

Exclusive Economic Zone (EEZ)
The concept of the EEZ was adopted through the 1982 United Nations Convention on the Law of the Sea (UNCLOS). It is an area of the ocean generally extending 200 nautical miles from shore, within which the coastal state has the right to explore and exploit, and the responsibility to conserve and manage, both living and non-living resources.

Food and Agriculture Organization (FAO)	Founded in 1945, the FAO is a specialised agency of the United Nations that leads international efforts to defeat hunger and improve nutrition and food security. The FAO is an intergovernmental organisation which serves 194 member nations, two associate members, and the European Union.
Fishing mortality (F)	F is a parameter used in fisheries population dynamics (which forms the basis of stock assessments) to account for the rate of loss of organisms from a population due to removals associated with fishing.
F_{MSY}	F_{MSY} is the fishing mortality rate that should, on average (all other things being equal) lead to a stock reaching B_{MSY}.
Ghost fishing	Ghost fishing occurs when Abandoned, Lost or otherwise Discarded Fishing Gear (ALDFG) — that is no longer under a fisher's control — continues to trap and kill fish, crustaceans, marine mammals, sea turtles and seabirds.
International Council for the Exploration of the Sea (ICES)	ICES, established in 1902, is an intergovernmental organisation whose main objective is to increase the scientific knowledge of the marine environment — in the North Atlantic Ocean, the Baltic Sea and the North Sea — and its living resources and to use this knowledge to provide advice to competent authorities. The main ICES deliverables are scientific publications, and scientific information and management advice – including catch limits - requested by member countries and international organisations and commissions.
Landing Obligation (LO)	The LO is a legal requirement in the UK which mandates that quota species cannot be discarded but must be retained and landed. Exemptions include prohibited species such as basking shark and common skate and species for which scientific evidence demonstrates high survival rates.
Minimum Conservation Reference Size (MCRS)	Species with a Minimum Conservation Reference Size[14] or "MCRS" is a minimum size that the fish must be to be sold for human consumption. The MCRS measure is intended to protect juvenile and undersized fish from being targeted to allow the species to breed before being removed from the sea.
Marine Protected Area (MPA)	MPAs are defined geographical areas of the marine environment designated and managed, through legal or other effective means, to protect habitats, species and processes essential for healthy, functioning marine ecosystems. There are several types of MPA in the UK including marine conservation zones (MCZ), special areas of conservation (SAC), special protection areas (SPA) and Ramsar sites.[15]

Maximum sustainable yield (MSY)	The Maximum Sustainable Yield (MSY) for a given fish stock is a theoretical maximum yield (catch) that can be taken from a stock in the long term under constant environmental conditions when that stock is at the biomass reference point B_{MSY}.
Non-permitted species	Marine species that cannot be targeted in a commercial fishery.
Non-quota species (NQS)	Non-quota species (NQS) are fish stocks which are not subject to a Total Allowable Catch (TAC) and are regulated nationally. They are often high-value, potentially vulnerable and generally data-poor species. NQS include all commercial shellfish apart from nephrops, and several demersal species such as squid and octopus in the English Channel.
Overfished	An overfished stock is a population of fish that is too low. A stock generally is considered overfished when it is exploited beyond an explicit limit set to ensure safe reproduction.
Overfishing	Overfishing occurs when the fishing mortality (F) is above F_{MSY}, in other words, the annual rate of catch is too high, such excessive fishing poses a high risk of stock depletion.
Pelagic species	Pelagic species refers to fish species found mainly in shoals in midwater or near the sea surface, such as mackerel and haddock.
Permitted species	Marine species that can be targeted in commercial fisheries.
Quota species (QS)	Quota Species (QS) are fish stocks which are subject to an annual Total Allowable Catch (TAC). These include shared or straddling stocks in the waters of coastal states. In the shared North Sea, quota species include cod, haddock, saithe, whiting, plaice and herring. Pelagic stocks of mackerel, blue whiting and Atlanto-scandian herring are shared between coastal states in the North East Atlantic.
Remote Electronic Monitoring (REM)	Remote electronic monitoring is a catch-all term that refers to integrated on-board systems that may include cameras, gear sensors, video storage, and Global Positioning System (GPS) units. These systems can capture comprehensive videos and are used to monitor fishing activity with associated sensors and positional information.[19]
Resilient marine habitat	The resilience of a marine habitat to fishing is if fishing rates can be sustained if the habitat, community or process recovers quickly from the fishing activity. The resilience of a habitat, community or process to fishing impacts can be measured as the inverse of the recovery time following a defined impact.

Sensitive marine habitats	Sensitivity is defined as the likelihood of change when a pressure (which could be chemical, physical, hydrological or biological) is applied to a species or habitat. It is a function of the ability of the habitat or species to tolerate or resist change (resistance or tolerance) and the rate (or time taken) for it to recover from impact (resilience or recovery).[22] Some benthic systems are characterised as sensitive as they are both easily disturbed and slow to recover. Sensitive habitats include those identified in the OSPAR List of Threatened and/or Declining Species and Habitats.
Total Allowable Catch (TAC)	Total Allowable Catches (TACs) are catch limits for quota species set by regulators for most commercial fish stocks. Coastal states negotiate TACs on an annual basis, based on scientific advice with the aim of achieving MSY. The International Council for the Exploration of the Sea (ICES) provides scientific advice for most of the fish stocks of interest to the EU and UK.
Vulnerable Marine Ecosystems (VMEs)	VMEs are groups of species, communities, or habitats that may be vulnerable to impacts from fishing activities. Vulnerability relates to the likelihood that a population, community or habitat will experience substantial alteration from short-term or chronic disturbance and the likelihood that it would recover and in what time frame. Significant adverse impacts are those that compromise the ecosystem integrity (structure and function) or cause significant loss of species richness, habitat or community type on more than a temporary basis.[24] VMEs include seamounts, hydrothermal vents, cold water corals and sponge fields.[25]

3. Aquaculture

3.1. Approach to the aquaculture TSC

The technical screening criteria (TSC) for aquaculture have been developed to support the substantial contribution to climate change mitigation. LNAS has developed TSC for fed-based aquaculture and non-fed aquaculture:

- For fed-based aquaculture, the focus is on reducing GHG emissions and improving feed sustainability, with thresholds set to reflect UK-specific emissions intensities.
- For non-fed aquaculture, the criteria reflect its low emissions profile and emphasise maintaining ecosystem benefits while ensuring no significant harm to biodiversity or water quality.
- Recirculating Aquaculture Systems (RAS) are excluded in this phase, due to their high energy use and unique impacts. LNAS recommends separate criteria be developed next phase of the UK Green Taxonomy development.

3.2. Marine and freshwater fed-based aquaculture TSC

Substantial Contribution Environmental Objective: Climate Change Mitigation

Description: Marine and freshwater fed-based aquaculture refers to economic activities that breed, raise and harvest fish, which require feed inputs, under controlled or semi-natural conditions. The economic activities in this category are associated with UK SIC code A32.

Context: This technical document provides the LNAS-recommended TSC for marine and freshwater fed-based aquaculture to make a substantial contribution to climate change mitigation. These criteria exclude land-based systems, such as Recirculating Aquaculture Systems (RAS), which have distinct environmental impacts and thus require a separate set of TSC. A marine or freshwater fed-based aquaculture farm manager or owner who seeks UK Green Taxonomy alignment would be required to demonstrate that their cradle to-farm-gate emissions do not exceed the established emission intensity threshold and adhere to feed sourcing requirements – these are outlined in Table 1. In addition, production would be required to comply with the Do No Significant Harm (DNSH) criteria to the other environmental objectives – these are outlined in Table 2.

How to navigate these criteria for fed-based aquaculture	
1. Substantial Contribution	A marine or freshwater fed-based aquaculture farm manager or owner must demonstrate that their cradle up to the farm-gate emissions from the production of fed-based aquaculture are lower than the emissions intensity threshold detailed in Table 1 alongside criteria to ensure that the emissions impact of feed is embodied in the Substantial Contribution criteria.
2. Do No Significant Harm	A marine or freshwater fed-based aquaculture farm manager or owner will then need to comply with the Do No Significant Harm (DNSH) criteria outlined in Table 2. The farm manager or owner has the option to instead demonstrate compliance with the DNSH criteria through a verified pass against certain sustainable aquaculture standards, these are listed in Table 3.
3. Proxy certification for DNSH	The standards in Table 3 can act as a proxy for a marine or freshwater fed-based aquaculture farm manager to demonstrate compliance with the DNSH criteria. These standards can only satisfy the DNSH criteria, the farm manager or owner must still demonstrate compliance with the Substantial Contribution criteria in Table 1.

Table 1: Demonstrating a Substantial Contribution to Climate Change Mitigation. The following table is the first test that an activity must show it meets to be deemed taxonomy-aligned. The below substantial contribution criteria set out how the production of marine and freshwater fed-based aquaculture can substantially contribute to climate change mitigation. LNAS developed an emissions threshold for kg of CO_2e emissions per tonne of live weight of fish produced, calculated as 50% of the range of cradle to-farm-gate emissions based on the best available data, prioritising recent UK-specific studies. **Due to the limited availability of comprehensive farm-level data, this threshold must be consulted on with the aquaculture industry to ensure that it does not inadvertently exclude UK sustainable aquaculture businesses**. The criteria also include an economic Feed Conversion Ratio (eFCR) threshold to minimise emissions from marine ingredients and a requirement that non-marine feed ingredients are not sourced from land that has been deforested or holds significant carbon value. These requirements are found before the mandatory DNSH assessment in Table 2.

Table 1: Fed-based aquaculture Demonstrating a Substantial Contribution to Climate Change Mitigation	
Substantial Contribution Criteria	An aquaculture farm manager or owner must demonstrate the following: 1. The **cradle up to the farm-gate emissions,** excluding those from land-use change (LUC), from the production of marine or freshwater fed-based aquaculture **are lower than 2515 kg of CO_2e emissions per tonne of live weight of fish produced:**[423] a. The cradle to-farm-gate GHG emissions are calculated using a GHG protocol-compliant GHG emissions assessment such as the GHG product standard[424] or ISO 22948:2020[425] b. Quantified cradle to-farm-gate GHG emissions are verified by an independent third party. 2. The economic Feed Conversion Ratio (eFCR) must be below the species-specific threshold detailed in Appendix 1: a. The eFCR is calculated with the following formula: $$eFCR = \frac{Feed\ use\ per\ cycle}{Net\ biomass\ (live\ weight)\ of\ aquatic\ animals\ produced\ at\ harvest.}$$ 3. Evidence that plant-based feed ingredients have not been sourced from deforested land or the conversion of land with high carbon value from 2020 onwards through the following: a. 100% of soya or soya-derived ingredients in the feed are certified by the Round Table for Responsible Soy (RTRS).[426]
	Rationale: Research shows that aquaculture has a lower carbon footprint compared to terrestrial animal proteins, although fed-based systems emit more than non-fed aquaculture. For example, Poore and Nemecek[427] and Gephart et al.[428] found that aquaculture had the lowest carbon footprint "24 gCO_2e per gram of protein" out of the compared sources (e.g. beef, mutton, cheese and pork), with beef at the highest "238 gCO_2e per gram of protein". Members agreed that, while fed-based aquaculture has a lower impact compared to other animal-based proteins, there is a need to incentivise higher emitting producers to reduce their emissions. In most fed-based aquaculture production, feed ingredients are the main source of GHG emissions.[429] For example, in 2018, feeding accounted for 61%

[423] Due to the limited availability of comprehensive farm-level data, LNAS members agreed that this threshold must be consulted on with the industry.
[424] GHG Protocol (n.d.) Product Life Cycle Accounting and Reporting Standard
[425] ISO 22948 (2020) 2020 Carbon footprint for seafood - Product category rules (CFP–PCR) for finfish
[426] Round Table for Responsible Soy (2021) Standard for Responsible Soy Production V4.0
[427] Poore and Nemecek (2018) Reducing food's environmental impact through producers and consumers
[428] Gephart et al. (2021) Environmental performance of blue foods
[429] Jin et al. (2024) Towards a low-carbon footprint: Status and prospects for aquaculture

and 75% of total emissions in Atlantic salmon production for Mowi and Grieg Seafood in Scotland, respectively.[430] These figures represent the lower boundary of figures found across the literature, which ranges from 75% to 94% of total emissions resulting from the feed.[431][432] The GHG emissions from feed also vary between ingredients, with marine-based ingredients typically having lower emissions than plant based ingredients.[433] Therefore, LNAS members agreed to develop criteria that include a GHG emissions threshold and metrics to capture the emissions impact of both marine and plant-based ingredients:

1. GHG emissions threshold:
    - The threshold is based on CO_2e emissions due to its relevance to climate change mitigation and comparability across sectors. The threshold covers cradle to-farm-gate emissions to capture the most significant source of GHGs in fed-based aquaculture—upstream feed inputs. [434] Emissions are measured per tonne of live weight of fish produced, aligning with lifecycle assessments (LCAs) and reflecting the direct GHG impact per unit of aquaculture output.
    - LNAS agreed on a range of cradle to-farm-gate emissions for UK marine and freshwater fed-based aquaculture at 2030-3000 kg CO_2e per tonne of live weight. LNAS determined this range from the LCA studies outlined in Appendix 2. To ensure consistency and relevance, LNAS agreed to make the following adjustments:
        i. Land Use Change (LUC) emissions were excluded in setting the range, as they are generally not included in most LCAs. Members agreed that the impact of LUC emissions is instead addressed through the feed sourcing criteria.
        ii. Studies from non-UK operations (e.g. Chile, Australia and the United States) were excluded in addition to Recirculating Aquaculture Systems (RAS) - which could skew the developed climate threshold.[435]
        iii. Due to the lack of comprehensive UK-specific data, particularly for freshwater trout, relevant LCA findings from Norwegian salmon supply chains[436] and French freshwater trout[437] studies were included. These studies were chosen for their similarities to UK production practices.
        iv. Only LCAs from 2014 onwards were considered. Older studies were excluded as advancements in feed technology and improvements in food conversion rates have generally lowered emission values over time.[438]

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[430] Hammer et al. (2022) Reducing carbon emissions in aquaculture: Using Carbon Disclosures to identify unbalanced mitigation strategies
[431] Winther et al. (2021) Greenhouse gas emissions of Norwegian seafoods: From comprehensive to simplified assessment
[432] Pelletier et al. (2009) Not All Salmon Are Created Equal: Life Cycle Assessment (LCA) of Global Salmon Farming Systems
[433] Newton et al. (2023) Life Cycle Inventories of marine ingredients
[434] Downstream emissions are not included within this boundary, such as transportation, storage and retail sales. These should be captured in other sectors of a UK Green Taxonomy.
[435] For example, while Gephart et al.'s research found a range of 2458-3581 kg CO_2e per tonne live weight of Atlantic salmon[435] this includes production from recirculating aquaculture systems (RAS) and production from Chile, Australia, the United States, and Canada providing higher emissions values compared to UK studies.
[436] Jonahsen et al. (2022) Greenhouse gas emissions of Norwegian salmon products
[437] Chen et al. (2015) Environmental assessment of trout farming in France by life cycle assessment: using bootstrapped principal component analysis to better define system classification.
[438] Kause et al. (2022) Improvement in feed efficiency and reduction in nutrient loading from rainbow trout farms: the role of selective breeding

	• The threshold of 2515 kg of CO_2e emissions per tonne of live weight of fish is calculated as 50% of this range. LNAS members agreed that this threshold will include the lowest emitters and act as a benchmark for higher-emitting producers. Whilst members developed this climate threshold based on relevant, best-available data, LNAS recognised that due to the limited availability of comprehensive farm-level data and lack of insight into how UK aquaculture industries are currently distributed within the range of emissions found in these LCAs, this threshold must be consulted on with industry. This consultation will serve to ensure that UK aquaculture businesses that are performing sustainably are not inadvertently excluded from the taxonomy. 2. Marine-based feed ingredients primarily include fishmeal and fish oil (FMFO) predominantly sourced from wild forage fish.[439] Members agreed that this criteria should include a metric to indicate whether producers are efficiently using marine ingredients and consequently lowering their emissions. The feed conversion ratio (FCR) provides a conventional measure of fish production efficiency; the weight of feed intake divided by weight gained by the fish. The smaller the FCR, the greater the feed use efficiency. LNAS members agreed to set economic feed conversion ratio (eFCR) thresholds rather than biological feed conversion ratio (bFCR) thresholds, as eFCR accounts for all the feed consumed along with the effect of feed wastage and mortalities, providing a more holistic representation of feed use and climate change impact. The eFCR thresholds that members agreed to use are aligned with the proposed targets within the Best Aquaculture Standard (BAP) standards for Atlantic salmon and freshwater trout, ensuring consistency at a global level. 3. Soya is now a major component of aquafeed and is projected to have the largest share of any ingredient in the aquafeed market between 2022 and 2028.[440] The implication of substituting greater ratios of fish-based with plant-based feed regimes in fed-based species can have significant deforestation and land conservation impacts and consequential GHG emissions impacts.[441][442] Research found that ~73% of GHG emissions from feed used in the Scottish aquaculture industry are attributed to the use of plant-based ingredients, with soy, rapeseed and wheat highlighted as high-emission sources[443] – soy in particular owed high land use change (LUC) emissions.[444] LNAS members agreed that the criteria should prevent producers from sourcing feed ingredients associated with ecological damage and high GHG emissions impacts:

[439] Boyd et al. (2022) The contribution of fisheries and aquaculture to the global protein supply
[440] MARKETSANDMARKETS (2023) Aquafeed Market by Species (Fish, Crustaceans, and Molluscs), Ingredient (Soybean, Corn, Fishmeal, Fish Oil, and Additives), Lifecycle (Starter Feed, Grower Feed, Finisher Feed, and Brooder Feed), Form, Additive, and Region - Global Forecast to 2028
[441] Aquaculture Stewardship Council (2021) New Feed Standard Will Tackle One of the Biggest Threats to Aquaculture's Reputation
[442] Food and Agriculture Organization (FAO) (2011) Demand supply of feed ingredients for farmed fish and crustaceans: trends and prospects.
[443] McGoohan et al. (2021) Fish farming in Scotland: Optimising its contribution to climate and environmental policies.
[444] Newton and Little (2018) Mapping the impacts of farmed Scottish salmon from a life cycle perspective

	• The criteria establish definitive timelines to curb the entry of products linked to deforestation and conversion into global supply chains in line with the new European Union Regulation on Deforestation-Free Products (EUDR).[445] A cut-off date of 2020 is given as this aligns with global goals to halt deforestation by 2020—as specified in the New York Declaration on Forests[446] and in the United Nations Sustainable Development Goals (SDGs)[447]—in the EUDR. This ensures consistency at the global level. • The criteria require that all soya-derived ingredients are certified by The Round Table on Responsible Soy (RTRS) Standard for Responsible Soy Production. The standard ensures zero deforestation and zero rainforest conversion in soybean production. Planet Tracker research found that the RTRS scheme emerges as the best standard in soy certification whilst also being one of the largest certifiers[448] and the Aquaculture Stewardship Council (ASC) Standards[449] include the same requirement as this criterion, ensuring consistency at the global level.

Table 2: Do No Significant Harm (DNSH). "Do No Significant Harm" is the second of the tests that an activity must show it meets to be deemed taxonomy-aligned. The below DNSH criteria sets out how the production of marine or freshwater fed-based aquaculture does not significantly harm any of the other five environmental objectives while making a substantial contribution to climate change mitigation. Fed-based aquaculture can have wider environmental impacts outside of climate change mitigation that need to be considered for investments in the sector. Based on that understanding, LNAS suggests the DNSH criteria could include the below list of potential impacts against the other five environmental objectives:

- **Climate change adaptation:** The ability of farming systems to adapt to climate change.
- **Biodiversity and ecosystems**: The impacts of farms on farmed species, wild populations and critical and sensitive habitats and species.
- **Sustainable use and protection of water:** The impacts of farms on water columns and benthic environments.
- **Pollution prevention and control:** The impacts of farms through poor management of supplies and waste streams.
- **Transition to the circular economy:** The impacts of farms through the inefficient use of resources.

[445] European Union (EU) (2023) Regulation (EU) 2023/1115 on deforestation-free products
[446] Forest Declaration Assessment (2014) New York Declaration on Forests
[447] United Nations (2017) Target 15.2 of the SDGs
[448] Planet Tracker (2022) Increased soy certification would decrease deforestation risk
[449] Aquaculture Stewardship Council (2019) Freshwater Trout Standard Version 1.2 and Aquaculture Stewardship Council (2022) Salmon Standard Version 1.4

It should be noted that GTAG set out a series of recommendations to the UK government on how to approach the development of DNSH criteria in the UK Green Taxonomy in its August 2023 paper.[450] There have been usability issues observed in DNSH criteria in other jurisdictions to date, which include issues due to the drafting of the criteria themselves, and GTAG provided advice on potential ways to fix these issues. Therefore LNAS recommends that the DNSH criteria for fed-based aquaculture be fully developed once the UK government has clarified its approach to DNSH in the UK Green Taxonomy. As such, this table sets out what LNAS considers as the environmental principles that should guide the DNSH criteria development for fed-based aquaculture. LNAS also recommends the potential metrics and thresholds to achieve the environmental principles – many of which are adhered to as normal for responsible management and required by many sustainable aquaculture standards such as the Best Aquaculture Practices (BAP) Standards[451] and the Aquaculture Stewardship Council's (ASC) Farm Standards.[452] These recommendations are pending the UK government's clarification of its way forward on DNSH.

Table 2: Fed-based aquaculture Demonstrating "Do No Significant Harm" to the remaining 5 environmental objectives	
Climate change adaptation	LNAS recommends that the UK government develop the DNSH criteria for climate change adaptation once the UK government has clarified its approach to adaptation in the UK Green Taxonomy. As such, this section provides feedback on the EU's approach along with the primary issues that should be considered when developing DNSH criteria for fed-based aquaculture: • LNAS members highlighted the feasibility issues of requiring that SME aquaculture farms perform a physical climate risk and vulnerability assessment, as used by the European Union. This is of particular importance for non-fed aquaculture in the UK.[453][454]
	Primary issues for consideration when developing DNSH adaptation criteria for fed-based aquaculture: • Temperature increases (sea and air). Both sea and air temperature increases can affect the health and growth rates, change the distribution of wild fish stocks and change the prevalence of pathogens. • Ocean acidification can affect the health of marine ecosystems and impact the food web that supports fed-based fish. • Extreme weather events, especially storms and heavy rainfall can lead to runoff and pollution, affect water quality and fish health and damage infrastructure. • Sea level rise could affect coastal aquaculture facilities.

[450] GFI, GTAG (2023) Streamlining and increasing the usability of the Do No Significant Harm (DNSH) criteria within the UK Green Taxonomy
[451] Best Aquaculture Practice (n.d.) BAP Standards & Guidelines
[452] Aquaculture Stewardship Council (n.d.) ASC Farm Standards
[453] In 2019, over 80% of English, Welsh and Northern Irish mussel, oyster and trout enterprises employed less than 5 people. See: Seafish (2022) Aquaculture production scales
[454] Approximately 95% of Scottish farmed salmon is now produced by a few large companies. See: SARF (2019) Scottish Aquaculture Research Forum

	• Changes in precipitation intensity and/or seasonal patterns impact freshwater availability and quality, affecting fish farming in freshwater environments.	
Biodiversity and ecosystems	**Environmental Principle:** Minimise or eliminate ecological harm from the use of wild fish and non-marine raw materials for feed and sea-lice control.	**Metrics and thresholds:** 1. Demonstrate that the reliance on marine ingredients does not place significant pressure on the sustainability stock levels of wild fisheries: a. The Fishmeal Forage Fish Dependency Ratio (FFDRm) and the Fish Oil Forage Fish Dependency Ratio (FFDRo) are below the species-specific thresholds detailed in Appendix 1. Formulas are provided in the same Appendix. 2. Evidence that marine feed ingredients are sustainably sourced: a. At least 75% of the fishmeal and fish oil come from sources that are either certified under a scheme that is an ISEAL member such as the Marine Stewardship Council (MSC) or MarinTrust certified. 3. Evidence that any wild fish used for sea-lice control, such as wrasse, follow responsible sourcing practices and adhere to the highest national or Inshore Fisheries and Conservation Authorities (IFCA) legal minimum conservation reference sizes (MCRS) for each species. These can be found in Appendix 3.[455]
	Rationale: 1. Fishmeal and fish oil are key components of fed aquaculture, comprising 76% and 71% of global resources used in aquafeeds (2019), respectively.[456] This reliance places pressure on the sustainability stock levels of wild fisheries, in addition to diverting potential food-grade fish, such as sardines and anchovies, from human consumption.[457] LNAS members agreed that DNSH criteria should reduce pressure on the sustainability stock levels of wild fisheries. The Forage Fish Dependency Ratio (FFDR) is a key metric for assessing reliance on wild fisheries. It is the ratio of the amount of wild fish-derived ingredients in feed, as fishmeal (FFDRm) and/or fish oil (FFDRo), to the amount of cultured fish produced. LNAS members agreed that the species-specific thresholds outlined in these criteria support the goal of reducing the inclusion rates of fishmeal and fish oil from wild sources in fed aquaculture, thereby minimising pressure on wild fish stocks. LNAS members recognised that while Fish In: Fish Out (FIFO) is another useful metric for this environmental principle, FFDR is preferred because it focuses on the amount of wild-caught fish used	

[455] The Angling Trust has complied the maximum national or Inshore Fisheries and Conservation Authorities (IFCA) legal minimum conservation reference sizes (MCRS) across UK species. See: Angling Trust (2024) Minimum Conservation Reference Sizes (MCRSs)
[456] Willer et al. (2022) Maximising sustainable nutrient production from coupled fisheries-aquaculture systems
[457] (ibid). found that in 2014, 460,000 metric tons of wild-caught fish were used to produce 179,000 metric tons of Scottish salmon. 76% of the wild-caught fish were edible for human consumption.

	to produce fishmeal and fish oil. LNAS members concluded that FFDR is a more effective indicator for reducing pressure on wild fish stocks. The FFDR thresholds provided are aligned with the Aquaculture Stewardship Council (ASC) standards for Atlantic salmon and freshwater trout, ensuring consistency at a global level. 2. LNAS members recognised that FFDR thresholds can reduce the inclusion rates of marine ingredients, however, they do not necessarily imply that the ingredients used are more sustainable or responsibly sourced. Therefore, members agreed that the criteria should include a requirement for evidence that the sourcing of marine ingredients for fish feed is sustainable. Many small wild pelagic fish, an important feed component as they are reduced into fishmeal and fish oil, are fished at capacity or overfished.[458] According to the International Fishmeal and Fish Oil Organization (IFFO), nearly half (46%) of small pelagic fish stocks are overfished.[459] Members agreed to require producers to demonstrate that the majority of their marine feed ingredients were sustainably sourced through a certification program. Members agreed to align with the Best Aquaculture Practice (BAP) Feed Mill Standard which requires that a minimum of 75% of marine ingredients used in salmonid feed be MarinTrust or Marine Stewardship Council (MSC) certified.[460] The ASC also requires that the fishmeal and fish oil used in feed come from fisheries certified under a scheme that is an ISEAL member, of which the MSC is the only fishery scheme that is a full member of ISEAL. 3. Wild fish, such as wrasse and lumpfish, can be an effective alternative to chemical treatments for lice control.[461] However, such species like wrasse are slow-growing and have low reproduction rates and are therefore vulnerable to local stock erosion.[462] LNAS members agreed that the criteria should address the unsustainable sourcing of these species. Minimum landing sizes or Minimum Conservation Reference Sizes (MCRSs) can be used to ensure that the stock is allowed to breed before being removed from the sea. In the UK, not all Inshore Fisheries and Conservation Authorities (IFCAs) or Devolved Authorities have adopted the same MCRS or set an MCRS for each species. Therefore, LNAS members agreed that the criteria should follow the highest national or Inshore Fisheries Conservation Authorities (IFCA) legal MCRSs for each species, further details of which can be found in Appendix 3. This is to ensure consistency across the UK. These requirements are in addition to any national[463] or IFCA requirements in place to protect wrasse species.

[458] FAO (2010) The State of World Fisheries and Aquaculture (SOFIA).
[459] Hilborn (2017) The status of forage fish
[460] Best Aquaculture Practices (2022) Feed Mill Standard
[461] Brooker et al. (2018) Sustainable production and use of cleaner fish for the biological control of sea lice: recent advances and current challenges
[462] IUCN (n.d.) SSC Groupers and Wrasses Specialist Group
[463] Marine Scotland will put in place a number of mandatory measures to protect wrasse species following consultation on their proposed mandatory fishing measures for Wild Wrasse harvesting. See: Gov.Scot (2020) Wild Wrasse harvesting – proposed mandatory fishing measures: consultation analysis

	Environmental Principle: Farmed fish are managed to minimise disease and escapees to protect the health and integrity of wild vulnerable populations.	**Metrics and thresholds:** 1. The farm is designed to minimise the release of aquatic animals and can evidence escape prevention planning and appropriate responses to the occurrence of escapees. This can include employee training programmes as well as net strength testing; appropriate net mesh size; net traceability; system robustness; predator management; record keeping and reporting of risk events. 2. Evidence of responsible practices to manage disease and parasites – including sea lice, such as biosecurity protocols, and quarantine systems.
	Rationale: 1. LNAS members agreed to promote improvements in systems designed to prevent fish escapes. Escaped fish can disrupt the genetic diversity of wild fish through competition and interbreeding, leading to reduced life expectancies, lower individual fitness and decreased populations over time.[464] LNAS members recognised that some escape events may be beyond the farmer's control, such as those caused by unexpected incidents like storm events. Therefore LNAS members agreed that criteria based on practices which improve farm systems, rather than setting a numerical threshold for annual escape events, are more effective and proportional indicators of responsible fish management that minimises the frequency and impact of escape events. 2. Due to the free flow of water through the aquaculture nets, infectious diseases and parasites, including sea lice, pose a significant threat to the health and survival of wild populations.[465] As aquaculture production continues to grow, members agreed that farm managers and owners should take measures to prevent farms from becoming breeding grounds for disease and causing excess mortalities amongst farmed and wild fish populations. LNAS members agreed that criteria based on practices, including biosecurity measures and quarantine systems, are effective indicators of responsible fish management that can minimise or prevent parasites and infectious diseases from being transmitted or re-transmitted and amplified between farmed and wild fish, to protect wild fish populations.[466]	
	Environmental Principle: Farmed fish are managed to	**Metrics and thresholds:** 1. In addition to the legal Veterinary Medicine Directorate (VMD) antibiotic requirements,[467] avoid the use of “Critically Important Antibiotics” in alignment with WHO guidelines on the use of

[464] Thorstad et al. (2008) Incidence and impacts of escaped farmed Atlantic salmon Salmo salar in nature.
[465] Dempster et al. (2021) Farmed salmonids drive the abundance, ecology and evolution of parasitic salmon lice in Norway
[466] Bera et al. (2018) Biosecurity in Aquaculture: An Overview
[467] HM Government (n.d.) Veterinary Medicine Directorate

<table>
<tr>
<td rowspan="2"></td>
<td>protect the health and welfare of the farmed species.</td>
<td>medically important antimicrobials in food-producing animals.[468] The full WHO list of critically important and highest-priority critically important antimicrobials is set out in Annex A.
2. Evidence of responsible practices to reduce the use of parasiticides and chemical treatments, including no more than 3 treatments of antibiotics over the most recent production cycle.
a. The medicines and products used on fish farms are approved and regulated through chemicals legislation by the Health and Safety Executive (HSE)[469] and through veterinary medicines regulations (VMR) by the Veterinary Medicines Directorate (VMD)[470]
b. The Scottish Environment Protection Agency (SEPA) regulatory guidance on practices to reduce the use of parasiticides and chemical treatments.[471]
3. Ensure all fish are stunned before killing with permitted methods only: mechanical percussive or electrical stunning:
○ The UK's Animal Welfare Committee provides recommendations to improve the welfare of farmed fish at the time of killing.[472]
4. Evidence of fish health and welfare training programmes, through Standard Operating Procedures (SOPs) and appropriate qualifications in areas such as fish husbandry, handling operations and slaughter methods. Training should be endorsed by a veterinarian who acknowledges the content as accurate, relevant and appropriate.</td>
</tr>
<tr>
<td colspan="2">Rationale:
1. LNAS members firmly agreed that the overuse of antimicrobials in food-producing animals poses significant environmental and public health risks, in particular the increased risk of antimicrobial resistance (AMR).[473] Misuse and overuse of antimicrobials can be used to compensate for poor animal welfare practices. Tackling the misuse and overuse of antimicrobials in animals is part of the UK's series of 5-year action plans for antimicrobial resistance, with new targets for food-producing animals in development.[474]</td>
</tr>
</table>

[468] World Health Organisation "WHO" (2017) Guidelines on use of medically important antimicrobials in food-producing animals
[469] HSE.GOV.UK (n.d.) Health and Safety Executive (HSE)
[470] HM Government (n.d.) Veterinary Medicines Directorate (VMD)
[471] Scottish Environment Protection Agency (2019) Protection of the Marine Environment: Discharges from Marine Pen Fish Farms
[472] Animal Welfare Committee (2023) Update to the 2014 FAWC Opinion on the welfare of farmed fish at the time of killing
[473] World Health Organisation (2017) Guidelines on the use of medically important antimicrobials in food-producing animals
[474] HM Government (2022) Tackling antimicrobial resistance 2019 to 2024: addendum to the UK's 5-year national action plan

Investors are also increasingly concerned about the systemic risks to portfolios posed by AMR.[475] The World Health Organisation (WHO) launched guidelines in 2017 on the use of medically important antimicrobials in food-producing animals, recommending that the food industry stop using antibiotics routinely to promote growth and prevent disease in healthy animals.[476] The Aquaculture Stewardship Council (ASC) and the Best Aquaculture Practices (BAP) finfish standards will not certify farms that use antibiotics designated by the WHO as critically important.[477][478] Aligning with the ASC, BAP and WHO requirements ensures consistency at the global level.

2. LNAS members agreed that the DNSH criteria should incentivise farmers to reduce their use of parasiticides and chemical treatment through equipment and management practice improvements. LNAS members recognised that some mortality events may be beyond the farmer's control, such as those caused by unexpected incidents like storm events. Therefore, in addition to legal requirements, LNAS members agreed that criteria based on practices which improve farm practices, rather than setting a numerical threshold for mortality events, are more effective indicators of responsible fish management that minimise the frequency and impact of escape events. Members also agreed that farms causing significant harm to fish welfare through regular mortality events will be excluded from taxonomy alignment due to the thresholds for the economic feed conversion ratio (eFCR) within the substantial contribution criteria. This is because the economic FCR is sensitive to the survival rate, which rises sharply if the survival rate drops significantly.[479] Thus, frequent mortality events would cause a producer to exceed the eFCR thresholds found in Appendix 1.
3. LNAS members agreed that fish should be rendered unconscious by mechanical percussive or electrical stunning before killing. This criterion aligns with the methods permitted by the Aquaculture Stewardship Council[480] and ensures that no fish suffers unnecessarily and that good welfare is preserved. Alignment with the ASC ensures consistency at the global level.
4. Members agreed that fish health and welfare should be promoted through staff training with Standard Operating Procedures (SOPs). Lack of or insufficient training of staff can lead to negative impacts on the fish, the environment and the producer. Members agreed that producers should be required to provide evidence of training and appropriate qualifications in key areas. As aligned with the ASC standard, this training must be endorsed by a veterinarian who acknowledges the content as accurate, relevant and appropriate, to ensure consistency at the global level.[481]

[475] Investor Action on Antimicrobial Resistance (2022) Progress Report: Investor efforts, achievements and opportunities ahead
[476] World Health Organisation (2017) Guidelines on the Use of Medically Important Antimicrobials in Food Producing Animals
[477] Aquaculture Stewardship Council (2024) Antibiotics in seafood farming
[478] Best Aquaculture Practices (2019) Stricter Stance on Antibiotics Use in Farms
[479] Best Aquaculture Practices (2023) BAP Farm Standard
[480] Aquaculture Stewardship Council (2022) Criterion 2.14 – Fish Health and Welfare
[481] Aquaculture Stewardship Council (2022) Criterion 2.14 – Fish Health and Welfare

Biodiversity and ecosystems	**Environmental Principle:** Minimise or eliminate harm to critical or sensitive habitats and species.	**Metrics and thresholds:** LNAS members agreed that the UK's devolved authorities' licensing requirements satisfy this environmental principle.[482] This includes continuous monitoring and annual disclosure that the farm still meets statutory requirements to minimise or eliminate harm to critical or sensitive habitats and species.
	Rationale: 1. LNAS members agreed that any farm manager or owner should be aware of any nearby critical or sensitive habitats, understand the potential impacts that their farm might have on those areas and have a functioning plan in place to address those potential impacts. LNAS members agreed that the legislative and regulatory framework in place satisfies these requirements, including that fish farms are continually monitored by relevant regulatory bodies, which are made available: a. In the UK, regulated by each devolved authority, finfish farms require an Environmental Impact Assessment if they are likely to have a significant effect on the environment for reasons that can include their size, nature or location.[483] b. If an authority concludes that a proposed development is likely to have a significant effect on a Natural site regulated under the Habitats Regulations, it must undertake an appropriate assessment of the implications for the conservation interests for which the area has been designated.[484]	
Sustainable use and protection of water and marine resources	**Environmental Principle:** Eliminate or minimise water column and benthic pollution impacts.	**Metrics and thresholds:** LNAS members agreed that the UK's devolved authorities' licensing requirements satisfy the environmental principle.[485] This includes continuous monitoring and annual disclosure that the farm still meets statutory requirements to eliminate or minimise water column and benthic environment impacts.
	Rationale: Fed fish farms can affect the water column and benthic environment through nutrients and organic matter derived from the activity of the farmed fish. Settleable solids, including faeces, uneaten food and fouling debris, can accumulate under farms; and excretion of metabolic wastes can affect water quality near the farm by increasing the levels of nitrogen (N) and phosphorus (P).[486] LNAS members agreed that the DNSH criteria aim to eliminate or minimise water column and benthic pollution impacts. LNAS members agreed that the legislative and regulatory framework in place to licence and monitor farms satisfy these requirements,	

[482] For Scotland see: Scottish Government Fish farm consents For England see: Seafish Aquaculture Regulatory Toolbox for England For Wales see: Aquaculture Regulatory Toolbox for Wales
[483] MMO (2022) Marine Licensing: impact assessments
[484] (ibid).
[485] For Scotland see: Scottish Government Fish farm consents For England see: Seafish Aquaculture Regulatory Toolbox for England For Wales see: Aquaculture Regulatory Toolbox for Wales
[486] Wang at al. (2012) Discharge of nutrient wastes from salmon farms: environmental effects, and potential for integrated multi-trophic aquaculture

	including that fish farms are continually monitored by relevant regulatory bodies, which are made available. The environment assessment screening associated with these licensing frameworks should account for, and potentially enforce action to address, the cumulative or indirect impacts of the farm on any identified receptor.[487][488]	
Pollution prevention and control	**Environmental Principle:** Manage farm supplies and waste appropriately to prevent pollution spills and loss of gear in the sea.	**Metrics and thresholds:** 1. Evidence that procedures are readily available to prevent chemical and fuel spills or leaks. These procedures should include safe, secure and properly managed storage and containment facilities for all fuel, lubricants and agricultural chemicals used, for example separating and labelling materials by hazard class. There should also be appropriate procedures for managing spills of chemicals and other products, with cleaning supplies and protective equipment readily available and designated staff that are trained to manage such spills and leaks. 2. Evidence that procedures are in place to reduce the risk of equipment failure, and reduce marine and plastic litter, such as ensuring that maintenance regimes are in place and followed and Standard Operating Procedures (SOPs) to promote good practice. If damaged, discarded, decommissioned or derelict aquaculture gear, including net pen facilities, feeding pipes and ropes, does occur then there is evidence of procedures in place, such as training staff in gear management to collect and remove the gear promptly from water bodies to avoid loss and harm to other fish and marine animals.
	Rationale: 1. LNAS members agreed that farm managers or owners should prevent the occurrence and impact of chemical and fuel spills. These spills can cause significant harm to marine wildlife and destroy habitats as well as contaminate food supply chains.[489] 2. LNAS members recognised that 'abandoned, lost or otherwise discarded fishing gear' (ALDFG) is a problem that is increasingly of concern whereby ALDFG or "ghost gear" continues to catch fish and other marine animals unselectively.[490] This is recognised in the 2023 United Nations Environment Programme (UNEP) zero draft treaty on plastics[491] and the Aquaculture Stewardship Council's	

[487] HM Government (2017) The Marine Works (Environment Impact Assessment) (Amendment) Regulations 2017
[488] HM Government (2017) The Marine Works (Environmental Impact Assessment (Scotland) Regulation 2017
[489] National Oceanic and Atmospheric Administration (NOAA) (n.d.) Oil and Chemical Spills.
[490] Do et al. (2023) Ghost fishing gear and their effect on ecosystem services – Identification and knowledge gaps
[491] UNEP Zero draft text of the international legally binding instrument on plastic pollution, including in the marine environment; Part II (9b) "Each Party shall cooperate and take effective measures, including appropriate marking, tracing and reporting requirements, to prevent, reduce and eliminate, abandoned, lost or otherwise discarded fishing gear containing plastic, taking into account internationally agreed rules, standards and recommended practices and procedures"

	(ASC) whitepaper on Marine litter and Aquaculture gear in Aquaculture.[492] LNAS members agreed that at minimum, measures should be in place to prevent the loss of gear and in the cases where gear loss occurs there are procedures in place to retrieve the gear.	
Transition to a circular economy	**Environmental Principle:** Resources are used efficiently on the farm and waste is responsibly re-used and recycled.	**Metrics and thresholds:** Evidence that there are measures in place to re-use and recycle plastics and other materials. This could include implementing systems such as waste collection points, wash plants, storage and inventory systems as well as developing management and staff awareness for the need to reuse equipment and fittings. Farm managers or owners should also evidence a recycling policy and associated management systems, e.g. developing a plastic inventory to track recyclable plastics and establishing facilities and SOPs for decommissioning equipment and recovering plastics and other components for recycling.
	Rationale: LNAS members agreed that aquaculture farmers should implement measures to increase resource circularity, and thus reduce resource use on farms. As aquaculture production continues to expand, encouraging farm owners and managers to reuse and recycle materials to prevent an equivalent increase in virgin, particularly plastic, resources is important to conserve natural resources globally.	

[492] Aquaculture Stewardship Council (2019) Whitepaper on Marine litter and Aquaculture gear in Aquaculture

Table 3: Fed-based aquaculture Ways in which an aquaculture farm manager or owner can demonstrate compliance with the "Do No Significant Harm" criteria
External verifiers can be either the relevant national competent authorities or an independent third-party verifier; having no conflict of interest with the operator of the activity or being involved in the development or operation of the activity. These proxies satisfy the full Do No Significant Harm (DNSH) criteria. However, the farm manager or owner must still demonstrate compliance with the Substantial Contribution criteria in Table 1. Standards which may be used as a proxy to satisfy these "Do No Significant Harm" criteria: 1. The aquaculture farm has an independently verified pass, by meeting 100 per cent of the requirements, against the following Aquaculture Stewardship Council's species Standards: a. ASC Salmon Standard Version 1.4[1] b. ASC Freshwater Trout Standard Version 1.2[1] 2. The aquaculture farm has an independently verified pass, by meeting 100 per cent of the requirements, against the following Best Aquaculture Practices (BAP) Standards: a. If published, the BAP Salmon Farm Standard Issue 3.0[1] can satisfy if the standard keeps the proposed FFDR threshold requirements. BAP Salmon Farm Standard Issue 2.4[1] does not satisfy these DNSH criteria as there is no FFDR threshold requirement.

3.3. Non-fed aquaculture TSC

Description: Non-fed aquaculture refers to economic activities that cultivate and harvest shellfish and aquatic plants under controlled or semi-natural conditions. The economic activities in this category are associated with the UK SIC code A32,

Substantial Contribution Environmental Objective: Climate Change Mitigation

Context: This technical document provides the LNAS recommended TSC for non-fed based aquaculture to make a substantial contribution to climate change mitigation. A non-fed aquaculture farm manager or owner who seeks UK Green Taxonomy alignment would not be required to meet a GHG emissions threshold owed to its significantly low, and potentially positive, climate impact – details of this are outlined in Table 1. Production would be required to comply with the DNSH criteria to other environmental objectives, LNAS has provided the environmental principles that should guide DNSH criteria development once the UK government has clarified its approach on DNSH – these are outlined in Table 2.

How to navigate these criteria for non-fed aquaculture	
1. Substantial Contribution	A farm manager or owner produces non-fed aquaculture, as detailed in Table 1.
2. Do No Significant Harm	A non-fed aquaculture farm manager or owner will then need to comply with the 'Do No Significant Harm' principles outlined in Table 2. The farm manager or owner has the option to instead demonstrate compliance through a verified pass against certain sustainable aquaculture standards, these are listed in Table 3.
3. Proxy certification for DNSH	The standards in Table 3 can act as a proxy for a non-fed aquaculture farm manager to demonstrate compliance with the 'Do No Significant Harm' principles. These standards can only satisfy the Do No Significant Harm (DNSH) principles.

Table 1: Demonstrating a substantial contribution to climate change mitigation (CMM). The following table is the first test that an activity must show it meets to be deemed taxonomy-aligned. The below substantial contribution criteria set out how the production of non-fed aquaculture can substantially contribute to climate change mitigation. LNAS members agreed that farm owners and managers who produce non-fed aquaculture should not be required to demonstrate compliance with the emissions threshold developed for marine and freshwater based aquaculture. However, members agreed that this approach should be reevaluated during the next TSC review period, to ensure that non-fed aquaculture continues to remain an activity with a considerably low climatic impact.

Table 1: Non-fed aquaculture Demonstrating a Substantial Contribution to Climate Change Mitigation	
Substantial Contribution Criteria	The farming activity produces non-fed aquaculture: seaweed or shellfish.
	Rationale: LNAS members agreed that non-fed aquaculture is highly unlikely to be performed in a way that undermines the climate change mitigation objective while offering one of the lowest GHG impact sources of protein (compared with other animal-based protein sources and some plant-based sources).[493][494] Further, seaweed cultivation has the potential to sequester carbon in sediments below farm sites, although this may be limited.[495][496] Research finds that the life-cycle emissions of non-fed aquaculture generate the lowest emissions across aquaculture and marine fishing. Specifically, the cradle up to farm-gate emissions of non-fed-based aquaculture in the UK was 131-250 kg of CO_2e emissions per tonne of live weight of fish.[497] This is significantly below the proposed emissions threshold of 2515 kg of CO_2e emissions per tonne of live weight of fish, used to qualify fed-based aquaculture as substantially contributing to climate change mitigation. Therefore, LNAS members agreed that the production of non-fed aquaculture does not need to demonstrate compliance with the emissions threshold developed for the marine and freshwater based aquaculture TSC. However, members firmly agreed that this should be reviewed at the next UK Green Taxonomy review period to prevent the risk of future emissions creep.

[493] Willer and Aldridge (2020) Sustainable bivalve farming can deliver food security in the tropics
[494] Gephart et al. (2021) Environmental performance of blue foods
[495] Ross et al. (2023) Potential role of seaweeds in climate change mitigation
[496] Pessarradona et al. (2024) Carbon removal and climate change mitigation by seaweed farming: A state of knowledge review
[497] McGoodan (2022) Assessing the environmental footprint of Scottish bivalve production

Table 2 “Do No Significant Harm (DNSH)”. DNSH is the second of the tests an activity must show it meets to be deemed taxonomy-aligned. The below DNSH principles set out how the production of non-fed aquaculture does not significantly harm any of the other five environmental objectives while making a substantial contribution to climate change mitigation. Non-fed aquaculture can have wider environmental impacts outside of climate change mitigation that need to be considered for investments in the sector. Based on that understanding, LNAS suggests the DNSH criteria could include the below list of potential impacts against the other environmental objectives:

- **Climate change adaptation:** The ability of farming systems to adapt to climate change.
- **Biodiversity and ecosystems:** The impacts of farms on wild populations and critical and sensitive habitats and species.
- **Sustainable use and protection of water:** The impacts of farms on water columns and benthic environments.
- **Circular economy:** The impacts of farms through inefficient use of resources and lack of reducing and reusing waste.
- **Pollution prevention and control:** The impacts of farms through poor management of supplies and waste streams.

It should be noted that GTAG set out a series of recommendations to the UK government on how to approach the development of DNSH criteria in the UK Green Taxonomy in its August 2023 paper.[498] There have been usability issues observed in DNSH criteria in other jurisdictions to date, which include issues due to the drafting of the criteria themselves, and GTAG provided advice on potential ways to fix these issues. Therefore LNAS recommends that the DNSH criteria for non-fed aquaculture be fully developed once the UK government has clarified its approach to DNSH in the UK Green Taxonomy. As such, this table sets out what LNAS considers as the environmental principles that should guide the DNSH criteria development for non-fed aquaculture. Many of these environmental principles are adhered to as normal for responsible management and required by many sustainable aquaculture standards, such as the Best Aquaculture Practices (BAP) Standards[499] and the Aquaculture Stewardship Council’s (ASC) Farm Standards.[500] These recommendations are pending the UK government's clarification of its way forward on DNSH.

[498] GFI, GTAG (2023) Streamlining and increasing the usability of the Do No Significant Harm (DNSH) criteria within the UK Green Taxonomy
[499] Best Aquaculture Practice (n.d.) BAP Standards & Guidelines
[500] Aquaculture Stewardship Council (n.d.) ASC Farm Standards

Table 2: Non-fed aquaculture Demonstrating "Do No Significant Harm" to the remaining 5 environmental objectives Environmental principles which should guide the DNSH criteria development	
Climate change adaptation	LNAS is advising on a revised approach to adaptation in the UK Green Taxonomy. LNAS aquaculture members highlighted the feasibility issues of requiring that aquaculture farms perform a physical risk and vulnerability assessment, especially for SMEs, which constitute most of the UK's non-fed aquaculture producers.[501] Consideration should also be given to how decisions over permitting could delay the availability of new species for production, and thus the development of the industry and its ability to adapt.
Biodiversity and ecosystems	The criteria should aim to ensure that the production of non-fed aquaculture: • Protects the health and integrity of wild vulnerable populations. • Minimises or eliminates harm to critical or sensitive habitats and species.
Sustainable use and protection of water and marine resources	The criteria should aim to ensure that the production of non-fed aquaculture eliminates or minimises water column and benthic pollution impacts.
Circular Economy	The criteria should aim to ensure that the production of non-fed aquaculture uses resources efficiently and that waste from plastics and other materials is reduced and reused.
Pollution prevention and control	The criteria should aim to ensure that the production of non-fed aquaculture manages farm supplies and waste appropriately to prevent pollution spills and loss of gear in the sea.

[501] In 2019, over 80% of English, Welsh and Northern Irish mussel, oyster and trout enterprises employed less than 5 people. See: Seafish (2022) Aquaculture production scales

Table 3: Non-Fed Aquaculture Ways in which an aquaculture farm manager or owner can demonstrate compliance with the "Do No Significant Harm" criteria
External verifiers can be either the relevant national competent authorities or an independent third-party verifier; having no conflict of interest with the operator of the activity or being involved in the development or operation of the activity. While this document does not provide DNSH criteria, LNAS agrees that the following standards and their qualifying criteria would satisfy the full Do No Significant Harm (DNSH) principles outlined in Table 2: 1. The aquaculture farm has an independently verified pass, by meeting 100 per cent of the requirements, against the following Aquaculture Stewardship Council's species Standards: a. ASC Bivalve Standard Version 1.1[502] b. ASC-MSC Seaweed Standard Version 1.01[503] 2. The aquaculture farm has an independently verified pass, by meeting 100 per cent of the requirements, against the following Best Aquaculture Practices (BAP) Standards: a. BAP Mollusk Farm Standard Issue 1.2[504]

[502] Aquaculture Stewardship Council (2019) Bivalve Standard Version 1.1
[503] Aquaculture Stewardship Council (2018) Seaweed (Algae) Standard Version 1.01
[504] Best Aquaculture Practice (2023) Mollusk Farms Standard Issue 1.2

3.4. Aquaculture appendices

Appendix 1: Species-specific thresholds and corresponding calculation formulas

	Economic Feed Conversion Ratio (eFCR)	Fishmeal Forage Fish Dependency Ratio (FFDRm)	Fish Oil Forage Fish Dependency Ratio (FFDRo)
Atlantic salmon	<1.1	<1.2	<2.52
Freshwater trout	<1.2	<1.5	<2.95

Economic Feed Conversion Ratio (eFCR)

$$eFCR = \frac{Feed\ use\ per\ cycle}{Net\ biomass\ (live\ weight)\ of\ aquatic\ animals\ produced\ at\ harvest.}$$

- The amount of feed used per cycle and net biomass of aquatic animals produced can be reported in metric tons or kilograms, but the same units shall be used for both in the calculation.

Fishmeal Forage Fish Dependency Ratio (FFDRm) and Fish Oil Forage Fish Dependency Ratio (FFDRo)

- The below calculation methodology is adapted from the ASC Salmon Standard:[505]

Feed Fish Dependency Ratio (FFDR) is the quantity of wild fish used per quantity of cultured fish produced. This measure can be calculated based on fishmeal (FM) and/or fish oil (FO). The dependency on wild forage fish resources shall be calculated for both FM and FO using the formulas noted below. This formula calculates the dependency of a single site on wild forage fish resources, independent of any other farm.

$$FFDRm = \frac{(\%\ fish\ meal\ in\ feed\ from\ forage\ fisheries)(eFCR)}{24}$$

$$FFDRo = \frac{(\%\ fish\ oil\ in\ feed\ from\ forage\ fisheries)(eFCR)}{5.0\ or\ 7.0,\ depending\ on\ source\ of\ fish}$$

[505] Aquaculture Stewardship Council (2022) Salmon Standard Version 1.4.

Where:

- eFCR is calculated using the above formula.
- The percentage of fishmeal and fish oil excludes fishmeal and fish oil derived from fisheries' byproducts.[506] Only fishmeal and fish oil that is derived directly from a pelagic fishery (e.g. anchoveta) or fisheries where the catch is directly reduced (such as krill or blue whiting) is to be included in the calculation of FFDR. Fishmeal and fish oil derived from fisheries' by-products (e.g. trimmings and offal and their derivatives such as squid liver powder, aquaculture-by-products such as shrimp head meal and ingredients derived from invasive aquatic species) should not be included because the FFDR is intended to be a calculation of direct dependency on wild fisheries. Whilst producers can exclude byproducts from their calculations, LNAS recommends that the inclusion of byproducts in FFDR calculations is re-evaluated during the next TSC review period.
- The amount of fishmeal in the diet is calculated back to live fish weight by using a yield of 24%.[507] This is an assumed average yield.
- The amount of fish oil in the diet is calculated back to live fish weight by using an average yield in accordance with this procedure:
- Group a - Fish oil originating from Peru and Chile and the Gulf of Mexico, five per cent yield of fish oil.
- Group b - Fish oil originating from the North Atlantic (Denmark, Norway, Iceland and the UK) seven per cent yield of fish oil
- If fish oil is used from other areas than mentioned above, they should be classified as belonging to "Group a" if documentation shows a yield of less than six per cent, and into "Group b" if documentation shows a yield of more than six per cent.
- FFDR is calculated for the grow-out period in the sea if the smolt phase does not go past 200 grams per smolt. If the smolt phase goes past 200g then FFDR is calculated based on all feed used from 200 grams and onwards. If needed, the grow-out site shall collect this data from the smolt supplier.

[506] Trimmings are defined as byproducts when fish are processed for human consumption or if whole fish is rejected for use of human consumption because the quality at the time of landing do not meet official regulations with regard to fish suitable for human consumption.
[507] Reference for FM and FO yields: Péron, G et al. (2010) Where do fishmeal and fish oil products come from? An analysis of the conversion ratios in the global fishmeal industry

Appendix 2: Studies used to determine the range of the cradle to-farm-gate GHG emissions of UK-based marine and freshwater fed-based aquaculture for the GHG emissions threshold described in Table 1

Year	Kg CO_2e per tonne live weight emissions[508]	Source
2022	3000	Johansen et al. (2022) "Greenhouse gas emissions of Norwegian salmon products". Research produced by SINTEF, "The Foundation for Industrial and Technical Research", into calculating the emission of 11 Norwegian salmon supply chains.[509]
2021	2800	MacLeod and Sposato (2021) "Quantifying and mitigating greenhouse gas emissions from Scottish aquaculture" Research produced by the Scottish Government Rural Affairs and the Environment Portfolio Strategic Research Programme. [510]
2019	2084	Philis et al. (2019) "Comparing Life Cycle Assessment (LCA) of Salmonid Aquaculture Production Systems: Status and Perspectives". This figure is taken from Newton and Little research but is not cited in Newton's paper. The authors obtained the figure directly from Newton for use in their paper. [511]
2017	2030-2320	Newton and Little (2017) "Mapping the impacts of farmed Scottish salmon from a life cycle perspective". Primary data was collected by a structured survey from a large international feed mill, six farms and a major processor, secondary data was collected from available literature on feed ingredients and background data from EcoInvent2.2. Figures can be found in the supplementary information.[512]
2015	2425-2647	Chen et al. (2015) "Environmental assessment of trout farming in France by life cycle assessment: using bootstrapped principal component analysis to better define system classification". Due to the lack of UK-based LCA studies on trout production, this figure is taken from research on French production.[513]

[508] LNAS members agreed to exclude land use change (LUC) emissions when setting the range, as they are generally not included in most LCAs. Members agreed that the impact of LUC emissions is instead addressed through the feed sourcing criteria.
[509] Johansen et al. (2022) Greenhouse gas emissions of Norwegian salmon products
[510] MacLeod and Sposato (2021) Quantifying and mitigating greenhouse gas emissions from Scottish aquaculture
[511] Philis et al. (2019) Comparing Life Cycle Assessment (LCA) of Salmonid Aquaculture Production Systems: Status and Perspective
[512] Newton and Little (2017) Mapping the impacts of farmed Scottish salmon from a life cycle perspective
[513] Chen et al. (2015) Environmental assessment of trout farming in France by life cycle assessment: using bootstrapped principal component analysis to better define system classification.

Appendix 3: Highest Minimum Conservation Reference Sizes (MCRSs) for wrasse species		
Species	Maximum National or IFCA legal MCRS	Maturity or restriction
Wrasse – Ballan (Labrus bergylta)	18cm	30cm
Wrasse – Corkwing	14cm	14cm
Wrasse – Cuckoo (Labrus mixtus)	12cm[514]	25cm
Wrasse - Goldsinny (Ctenolabrus rupestris)	12cm	14cm
Wrasse – Rock cook. (Centrolabrus exoletus)	12cm	14cm

3.5. Aquaculture technical glossary

Abandoned, lost or otherwise discarded fishing gear (ALDFG)

The term "abandoned fishing gear" means fishing gear over which that operator/owner has control and that could be retrieved by the owner/operator but is deliberately left at sea due to force majeure or other unforeseen reasons. The term "lost fishing gear" means fishing gear over that the owner/operator has accidentally lost control and that cannot be located and/or retrieved by the owner/operator. The term "discarded fishing gear" means fishing gear that is released at sea without any attempt for further control or recovery by the owner/operator.

Antimicrobial resistance (AMR) from antibiotic use in animal production

Antimicrobial resistance occurs when infectious agents (bacteria, viruses, fungi and parasites) evolve over time and acquire new characteristics that reduce or stop their susceptibility to antimicrobials. The inappropriate and excessive use of antimicrobials in animal production contributes to the development of AMR.

Benthic environment

The ecological region at the lowest level of a body of water, including the sediment surface and sub-surface layers.

[514] This MCRS figure is taken from the Scottish Government's proposed mandatory fishing measures for Wild Wrasse harvesting. See: GOV.SCOT (2020) Wild Wrasse harvesting – proposed mandatory fishing measures: consultation analysis

Biosecurity measures	Practices and procedures implemented in aquaculture to minimise the risk of introducing and spreading infectious diseases among aquatic animals. These measures help protect the health of farmed species and prevent the spread of pathogens to other sites and susceptible species.
Cradle to farm-gate assessment	Cradle to farm-gate refers to an environmental assessment approach that evaluates the impacts of agricultural and aquaculture products from their inception (cradle) to the point they leave the farm (farm-gate). This method is part of a broader Life Cycle Assessment (LCA) framework, which helps in understanding the environmental footprint of products.
Economic Feed Conversion Ratio (eFCR)	In aquaculture, the Economic Feed Conversion Ratio (eFCR) measures the amount of feed required to produce a unit of biomass, typically expressed as kilograms of feed per kilogram of fish weight gained. The eFCR takes into account not only the feed consumed but also the economic aspects such as feed losses and mortalities.
Fed-based aquaculture	Fed-based aquaculture refers to the practice of raising aquatic animals using feeds to meet their nutritional needs.
Fishmeal Forage Dependency Ratio	The Fishmeal Forage Dependency Ratio is a metric used to assess the sustainability of aquaculture feeds by measuring the dependency on wild-caught fish for fishmeal production.
Fish in: Fish out (FIFO)	A ratio to measure the amount of wild fish needed to produce a unit of farmed fish. It helps assess the efficiency and sustainability of fish feed practices by indicating the balance between wild fish inputs and farmed fish outputs.
GHG-protocol	The Greenhouse Gas (GHG) Protocol is a comprehensive global standardised framework for measuring and managing greenhouse gas emissions from private and public sector operations, value chains and mitigation actions.
ISEAL	An international organisation that sets globally recognised codes of good practice for sustainability standards.
Land use change (LUC) emissions	Land use change emissions refer to the greenhouse gases released into the atmosphere due to changes in how land is used. This can include activities such as deforestation, conversion of forests to agricultural land, urban development and other alterations of natural landscapes.
Life-cycle carbon assessment (LCA)	A Life Cycle Assessment (LCA) is a systematic method used to evaluate the environmental impacts associated with all stages of a product's life. This comprehensive approach helps in understanding the cumulative environmental effects of a product, process, or service.

Live weight of fish produce	Live weight of fishery products is designed to represent the actual weight of the fishery product as it was harvested or taken from the water before being subjected to any gutting, processing or other operations.
Minimum conservation reference sizes (MCRS)	The smallest size at which a marine species can be legally caught, ensuring that immature individuals are not harvested. This helps maintain sustainable fish populations by allowing young fish to grow and reproduce.
Non-fed aquaculture	Non-fed aquaculture refers to the practice of farming aquatic organisms that do not require feed inputs. Instead, these organisms rely on natural food sources available in their environment.
Round Table for Responsible Soy (RTRS)	The Round Table on Responsible Soy Association (RTRS) is a global, multi-stakeholder initiative established in 2006 to promote the sustainable production, trade and use of soy. RTRS has developed a global certification standard for responsible soy production, which includes criteria for sustainable farming practices, environmental protection, and social responsibility.
Upstream emissions	Upstream emissions refer to the greenhouse gas emissions that occur during the production and supply of goods and services before they reach the end user. In this TSC, upstream emissions are used to describe GHG emissions generated before the farm activities (largely associated with feed production).

4. General annex

4.4. Annex A: Critically important antimicrobials to human medicine

The antimicrobials set out below have been classified by the World Health Organisation as Critically Important to Human Medicine. The antimicrobials are categorised based on priority based on potential impacts on human health. This annex is relevant for the livestock production TSC and the fed-based aquaculture TSC.

Annex A: Critically important antimicrobials to human medicine
Highest Priority Critically Important Antimicrobials
Cephalosporins (3rd, 4th and 5th generation)
Glycopeptides
Macrolides and ketolides
Polymyxins
Quinolones
High Priority Critically Important Antimicrobials
Aminoglycosides
Ansamycins
Carbapenems and other penems
Glycylcyclines
Lipopeptides
Monobactams
Oxazolidinones
Penicillins (antipseudomonal)
Penicillins (antipseudomonal)
Penicillins (aminopenicillins with betalactamase inhibitors)

Phosphonic acid derivatives
Drugs used solely to treat tuberculosis or other mycobacterial diseases
High Priority Critically Important Antimicrobials
Amphenicols
Cephalosporins (1st and 2nd generation) and NA cephamycins