

FARMING FOR NET ZERO: TRANSITIONING SCOTTISH AGRICULTURE

January 2024

Work undertaken by



SAC

CONSULTING

Part of Scotland's
Rural College (SRUC)

This report has been prepared for
WWF and Soil Association.

Farming for Net Zero: Transitioning Scottish Agriculture

Date: March 2024

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This report has been prepared exclusively for the use of WWF and Soil Association, based on information supplied by from 3rd party sources outlined within report.

All information is correct at time of writing.

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Revision Number	Date	Version	Author	Reviewer	Checker
1.1	9th Dec 23	DRAFT	S. Buckingham	F.Salter	
1.2	19th March 24	FINAL	S.Buckingham	F.Salter	

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Introduction

The Agricultural Reform Programme published by the Scottish Government in 2023 introduces a new framework from the Scottish Government. This reform depicts how support will be given to the farming and food production sector in Scotland. Focusing on sustainable and regenerative agricultural practices (such as those outlined in Appendix 1), the criteria for which farmers can claim support payments is changing. In the new tiered framework farmers will need to comply with existing cross compliance requirements, but additionally have the options to introduce other management options onto their farm. The proposed scheme is based on four tiers, with Tier 1 focussing on a basic payment, Tier 2 being an enhanced payment and Tiers 3 & 4 aimed at more integrated projects, as shown in Figure 1. Farmers can select and adopt a range of management practice options available that best suit their farm business type. More information on the four tiers can be found in Appendix 2. However, First Minister of Scotland announced that 70% of future support will be in the form of direct payments with the remaining 30% of the cash will be for targeted measures like creating wetlands or restoring peatlands.¹

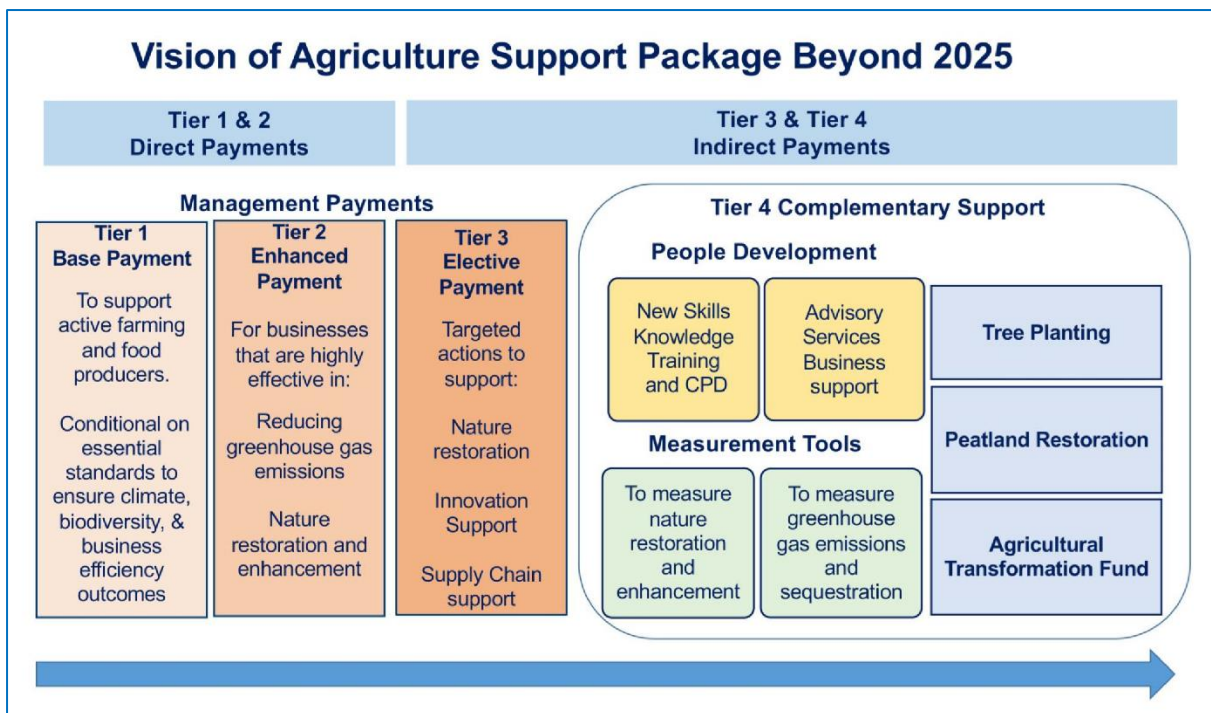


Figure 1: Vision of Agriculture Support Packages Beyond 2025²

This project reviews Scottish Government’s Agriculture Reform Programme List of Measures³, which comprise a range of climate and nature-friendly (regenerative) practices. These measures will form the basis of the Tier 2 Enhanced Payment. Current guidance indicates that from 2026, 50% of basic farm payment will move from Tier 1 into

¹ Scottish farmers win battle over food subsidies – BBC News

² Scottish Government (2022) *Delivering our Vision for Scottish Agriculture: Proposals for a new Agriculture Bill*.

³ Agricultural Reform List of Measures (ruralpayments.org). <https://www.ruralpayments.org/topics/agricultural-reform-programme/arp-list-of-measures/>

Tier 2. Unlike Tier 3, Tier 2 will be non-competitive and open to all eligible farm enterprises. This project will review the List of Measures against the current policy framework and against the future 4-Tier payment system.

Project Outline

This project will comprise three key phases outlined below,

(1) Analysis of proposed 4-tier scheme design:

Management practices proposed by The Scottish Government's Agricultural Reform List of Measures will be mapped across to the proposed 4-tier payment framework set out by Agricultural Reform Route Map. Through the mapping process, knowledge gaps between measures outlined and the proposed policy framework will be identified.

(2) Review GHG mitigation potential and economic costs

Provide a rapid evidence assessment of the GHG emission mitigation potential across the agricultural reform measures as well as an indication of the economic costs associated with their implementation.

(3) Investigate the scale of uptake required to meet net zero targets.

Review the level of uptake that will be required to reach GHG emissions reductions that are consistent with climate change targets. This will include discussing the uptake of future policy schemes (based on land cover), which will be necessary to achieve emission reductions to remain static at 2021 levels. In addition, the review will examine how future schemes can help to achieve The Climate Change Plan Update target of meeting Scotland's emissions reduction targets over the period to 2032.

Discussion

Phase 1: Mapping measures to the 4-tier payment framework

Full descriptions of Scottish Government's agricultural reform list of measures and the proposed 4-tier payment framework were reviewed and are provided in Appendix 1 and 2. The description of Scottish Government's Agricultural Reform (agri-reform) List of Measures were reviewed with respect to Tiers 1 to 4 payment categories of the Agricultural Reform Programme's proposed 4-tiered rural payments framework. Academic expertise, knowledge and judgement were used to allocate each agri-reform measure to the different payment tiers based on two key criteria:

1. Where measures currently sit in relation to current basic payment (and therefore fall within Tier 1) and agri-environmental schemes and how these financial aides overlap with the proposed 4-tier system; and
2. Where there is scope for these measures to be easily adopted (financially and practically) in Tiers 1 and 2 by land managers to contribute to GHG reductions, net zero targets, and nature restoration.

Throughout the mapping exercise, justifications are provided that describe each allocation decision (Table 1) as well as explanations for why some measures may fall into

more than one tier-payment category. Soils Association reviewed the mapping of measures (Table 1, a-f) to minimise bias and to allow for wider feedback. This process allows for interactions and synergies between tiers and measures to be outlined as well as inform where knowledge gaps exist (based on academic judgement, and expertise). Table 1 also provides indication of support that may be required for the implementation of measures across tiers, for example the level of resources, financial implications and technical educational/knowledge required to adopt each measure.

Table 1 (a-f): Agri-reform measures mapped to the proposed 4-Tier payment scheme. Green boxes refer to measures that are believed to be most readily adopted and so should be included in Tier 1. Red refers to measures that are not easily adopted and so should not be a requirement of Tier 1. Tiers 2, 3 and 4 outline optional measures that would require additional support to implement.

(a) In Field – Cultivated Soils (Arable Crops – including fodder crops; Grassland – improved, Grassland – temporary)

Measure	Tier 1: Basic Payment	Tier 2: Elective payment	Tier 3/Tier 4: Complementary support
Winter cover	Should be achievable for most and relates to minimum soil cover guidelines in GAEC 4, therefore could be included in basic payments.	Expanded to include cover crops, winter stubble within rotations (i.e. retention of a specific %).	Could target specific winter cover to favour granivorous birds/supplementary feeding or other ecosystem services. Tier 4 to provide knowledge exchange and training.
Efficient / Reduced use of inorganic fertilisers and lime	Soil testing & nutrient management plans should already exist with nutrient(s) applied in accordance with recommendations. (particularly those in NVZs). Soil testing forms a key component of the Whole Farm Plan.	Additional measures to reduce and improve efficiency (e.g. using precision agriculture & soil mapping techniques to improve application efficiency, replace inorganic N with green & animal manures or through incorporation of legumes, include livestock grazing – see below).	Could be included in Tier 3 as part of targeted actions nature restoration practices and/or innovation support as well as capital investment to acquire resources (e.g. machinery) to enable implementation. Tier 4 funding could contribute to training (e.g. new machinery and software)
Efficient / Reduced use of synthetic pesticides	Completion of an IPM plan should/could be part of the whole farm plan (particularly arable). There are recommendations for pesticide use and these should be adhered to as a minimum.	Tier 2 funding can be applied if additional measures are applied (e.g. precision application etc.).	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support as well as capital investment to acquire resources (e.g. machinery) to enable implementation. Tier 4 funding could contribute to training (e.g. new machinery, knowledge exchange and software).
Diversify crop rotation and break crop rotation period (esp. for root crop)	Should be achievable as monocropping is not recommended as standard practice and should be avoided. There could be a minimum number of crops in a rotation (e.g. 3 crops).	Tier 2 measures could expand the crops & diversity within the rotation (e.g. 5 crops).	Could be included in Tier 3 nature restoration practices and capital investment to acquire resources to enable implementation. Tier 4 funding could contribute to training (e.g. knowledge exchange).
Bird friendly Crop Operations	Cutting/harvesting in a wildlife friendly manner should be included as best practice.	Altering cutting date to preserve nests adopted according to the species being targeted.	More targeted actions – management for corncrake, skylark plots, wader management/scrapes.
Silvo-pastures	Ancient wood pasture should be retained under GAEC irrespective of tree size.	Could be included in Tier 2 as an enhanced payment for those able to implement on-farm.	Targeted action for selective sites with woodlands, requires planting effort to maintain and restore landscape. Risks in productive areas to field drains, which could impact on viability. As above the time and costs to establish means that additional incentives may be required. This may be applicable also under Tier 4 depending on tree density.

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Minimum/No Tillage	Not applicable or suitable for all. Farm dependent – variety of factors to consider (crop rotation, weed management, soil type & suitability, compaction). Not one rule fits all to fit in Tier 1.	To adopt where suitable, new machinery may be needed (financial implications).	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support as well as capital investment to acquire resources (e.g. machinery) to enable implementation.
Use of N fixing crops	Not applicable or suitable for all. Farm dependent – variety of factors to consider and requires more planning to incorporate into Tier 1. (Soil-crop interactions need to be considered, ease of crop separation, potentially different equipment needed/additional knowledge base & proof of concept), more information needed on optimum mixtures.	Trial and error approach sometimes needed (not all capable of this) so Tier 2 funding would be more suitable. Crops may not be economically viable to grow in some areas, and there may be insufficient market. Depends on land use & potential benefits – e.g. beneficial for protein content relating to animal feed but there may be technical difficulties in separating crop-legume.	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support as well as capital investment to acquire resources (e.g. machinery) to enable implementation. Tier 4 funding could contribute to training (e.g. new machinery and knowledge exchange).
Inter-cropping, under-cropping and mixed cropping (e.g. peas and barley) and avoid monoculture	Not applicable or suitable for all. Intercropping can be agronomically difficult and there can be problems separating crops as well as contamination that need consideration. More guidance/knowledge/planning is needed.	Could be included in Tier 2 as an enhanced payment for those able to implement on-farm.	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support as well as capital investment to acquire resources (e.g. machinery) to enable implementation. Tier 4 funding could contribute to training (e.g. new machinery, knowledge exchange and software).
Arable/ley rotations (transition from arable to arable/livestock mix)	Not applicable or suitable for all and further assistance (educational and resources) in order to implement on-farm.	Occurs within mixed farms, therefore, should be easier to implement and incorporate animals into arable rotations. Inclusion of leys is a common practice in organic farms. However, there may be challenges for arable farms due to a lack of access to livestock, lack of knowledge of animal husbandry/roots to market, lack of infrastructure (watering points/stock proof boundaries) etc.	Arable farms likely to need additional support through further education (animal handling/health/nutrition/husbandry), physical improvements required (fence/water etc.). Funding to facilitate delivery could sit under an 'elective' payment, Tier 3 funding could provide capital investment to acquire resources (e.g. machinery) to enable implementation. Tier 4 funding could contribute to training (e.g. new machinery, knowledge exchange and software).
Biodiversity cropping and silvo-arable systems	Not applicable or suitable for all and further assistance (educational and resources) in order to implement on-farm.	Tier 2 could include margins that are naturally regenerated (width greater than 5 m), or wildlife friendly margins of a width <5 m, or conservation headlands.	Tier 3 elective could focus on margins that are more difficult to establish/maintain (e.g. wildflower mixes or wild bird cover) with a minimum width requirement e.g. 6 m, or infield margins/beetle banks. Or separation between Tier 2 and Tier 3 margins could focus on outcomes based on a scorecard system (as in development by NatureScot). Strong evidence show that result based schemes can enhance the value of AES habitats. Research indicates that low condition of AES habitats limits their value.

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Silvo-arable systems	Not applicable or suitable for all and further assistance (educational and resources) in order to implement on-farm.	Planting of trees within arable systems is included under enhanced payment but this may not be sufficient incentive.	With trees taking time to establish it is possible that silvo-arable systems will need Tier 3 (or Tier 4 woodland creation) level support to incentivise. Tier 3 could also provide capital investment to acquire resources (e.g. machinery) to enable implementation. Tier 4 funding could contribute to training (e.g. new machinery, knowledge exchange and software).
Diverse sward species content (legumes-herb-grass mixtures) and use of herbal leys	Not applicable or suitable for all and further assistance (educational and resources) in order to implement on-farm.	Achievable with investment. This option is relevant to productive grassland systems but less so to extensive systems.	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support as well as capital investment to acquire resources (e.g. machinery) to enable implementation. Tier 4 funding could contribute to training (e.g. new machinery, knowledge exchange and software).
Regenerative grazing (mob, strip, adaptive multi-paddock grazing) on improved grassland	Not applicable or suitable for all and further assistance (educational and resources) in order to implement on-farm.	Achievable with education (complexity of setting up and determining stocking densities and timings should not be underestimated) and some investment (time & fences/collars/watering points mostly).	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support. Training and capital funding (e.g. no fence collars, alternative watering systems) to facilitate delivery.

(b) In Field – Margins and Uncultivated Features (Arable crops – including fodder crops; Grassland – improved; Grassland – semi improved; Grassland – Unimproved and Species Rich Grassland; Water; Wetland; Woodland; Scrub; Heath / Moorland; Bog; Coastal dune/marsh).

Measure	Tier 1: Basic Payment	Tier 2: Elective payment	Tier 3/Tier 4: Complementary support
Arable and Silage/Hay Crop Margins	A minimum width could be included into 'best practice'.	Width could be expanded and included in Tier 2 as an enhanced payment for those able to implement on-farm.	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support.
Enhance existing Hedgerows	Where already in existence hedgerow maintenance should be under Tier 1 and should extend beyond current GAEC to prevent degeneration (but can be costly, labour intensive and skilled labour needed).	This should be encouraged in Tier 2 payments – with greater focus on frequency and staggering cutting. Achievable with investment.	Potential to have a hybrid approach with Tier 3 moving to a result-based approach based on scorecard outcomes. Training to fill skills gap in techniques to rejuvenate hedgerows (e.g. coppicing/laying).
Water Margins	This can be complex and have significant costs to grassland farms relating to possible land out of production and fencing. Retention of buffer strips adjacent to watercourses to mitigate diffuse pollution (relate to GAEC 1 which refers to buffer zones but not water margins).	Potential for narrow fenced water margins in some areas.	Wider margins under this tier, alongside the potential for result based payment scheme. Planting of riparian woodland has biodiversity and climate benefits, helping to reduce fluctuations in water temperatures – relevant to Tier 4 woodland creation.

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Retain and Enhance in Field Biodiversity Cropping and Features	Covers a wide range of options, which vary in ease of implementation. Narrow buffer strips adjacent to wetlands could be relevant to Tier 1.	Potential for some to incorporate this as Tier 2 activities. For example, the establishment of wider buffer strips adjacent to lowland bog/peatland and wetland could be achieved in some areas as well as the implementation of forage brassicas for wild bird, mixed-species grass strips and margins.	A lot to take on and so would require investment in education/time and money. Converting Arable at Risk of Erosion or Flooding to Low-input Grassland has significant economic impact Beetle banks; wild bird cover; Pollinator strips and margins. Infield options if requiring a buffer re pesticide applications take considerable land out of production.
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(c) Uncultivated Permanent Habitats (Arable crops – including fodder crops; Grassland – improved; Grassland – semi improved; Grassland – Unimproved and Species Rich Grassland; Water; Wetland; Woodland; Scrub; Heath/Moorland; Bog/Peatland; Coastal dune/marsh.)

Measure	Tier 1: Basic Payment	Tier 2: Elective payment	Tier 3/Tier 4: Complementary support
Manage Grazed Habitats	Whole farm plan includes protections for peatlands and wetlands. This should be expanded to include other habitats of high nature value (e.g. species rich grasslands).	Tier 2 enhanced conditionality could include management plans, grazing regimes to protect/enhance habitat quality. Bracken/deer control where these are impacting on the ecological integrity of upland habitats.	Species targeted action – corncrake/hen harrier management. Habitat creation – wetlands, ponds, species-rich grasslands.
Introduction of Small-Scale Tree and Shrub Planting	Not applicable or suitable for all and further assistance (educational and resources) in order to implement on-farm.	Could be included under Tier 2 depending on delivery mechanism. Should not be compulsory but encouraged.	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support. Maybe applicable to Tier 4 (woodland creation).
Retain Traditional Cattle	Not applicable to all and so should not be included in basic payments.	Not every farmer has 'traditional' cattle and so should not be in Tier 1. Doesn't align to Tier 3 or 4.	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support.
Summer Hill Cattle Grazing	Not applicable or suitable for all and further assistance (educational and resources) in order to implement on-farm.	It is not clear why this is just summer grazing. Winter hill grazing shows promising results and cattle grazing have the potential to help reduce bracken dominance. Here potential under Tier 2 to combine with reduced supplementary feeding. Potential to introduce cattle into sheep systems.	Potential to include technologies to better target grazing management – e.g. no fence collars, or implementation of adaptive multi-paddock grazing, implementation of infrastructure (e.g. watering points/fencing). Outcome-based here would be preferred as options would need to show positive change.

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(d) Beef Sector

Measure	Tier 1: Basic Payment	Tier 2: Elective payment	Tier 3/Tier 4: Complementary support
Supporting and incentivising improved beef cattle nutrition	Should already be implemented in basic payment.	Could be included in Tier 2 as an elective payment for those able to implement on-farm.	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support.
Supporting and incentivising genetic improvement of beef cattle	Incorporate into the whole farm plan – Scottish Suckler Beef Support Scheme to help cut emissions intensity and make beef production more efficient.	Uptake of additional genetic improvement techniques that may require additional support to adopt (E.g. selective culling).	Inclusion of more new/innovative/high-tech approaches (bigger risk).
Support maintaining and improving beef cattle health	Should already be implemented in basic payment.	Uptake of additional practices (beyond those conducted within Tier 1) that contribute to cattle health improvements	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support.
Supporting appropriate uptake of feed products which reduce enteric methane emissions in beef cattle	Not applicable or suitable for all and further assistance (educational and resources) in order to implement on-farm.	Could be included in Tier 2 as an elective payment for those able to implement on-farm.	Innovative approach to take on (seaweed, 3-NOP).

(e) Dairy Sector

Measure	Tier 1: Basic Payment	Tier 2: Elective payment	Tier 3/Tier 4: Complementary support
Supporting and incentivising improved dairy cattle nutrition	Should already be implemented in basic payment.	Could be included in Tier 2 as an elective payment for those able to implement on-farm.	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support.
Support maintaining and improving dairy cattle health	Should already be implemented in basic payment.	Could be included in Tier 2 as an elective payment for those able to implement on-farm.	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support.
Support and incentivise genetic improvement of dairy cattle	Not applicable or suitable for all and further assistance (educational and resources) in order to implement on-farm.	Uptake of additional genetic improvement techniques that may require additional support to adopt	Inclusion of more new/innovative/high-tech approaches (bigger risk).

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Supporting appropriate uptake of feed products with reduce enteric methane emissions in dairy cattle	Not applicable or suitable for all and further assistance (educational and resources) in order to implement on-farm.	Could be included in Tier 2 as an elective payment for those able to implement on-farm.	Innovative approach to take on (seaweed, 3-NOP).
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(e) Sheep Sector

Measure	Tier 1: Basic Payment	Tier 2: Elective payment	Tier 3/Tier 4: Complementary support
Supporting and incentivising improved sheep nutrition	Should already be implemented in basic payment.	Could be included in Tier 2 as an elective payment for those able to implement on-farm.	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support.
Support maintaining and improving sheep health	Should already be implemented in basic payment	Could be included in Tier 2 as an elective payment for those able to implement on-farm.	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support.
Support and incentivise genetic improvement of sheep	Not applicable or suitable for all and further assistance (educational and resources) in order to implement on-farm.	Uptake of additional genetic improvement techniques that may require additional support to adopt	Inclusion of more new/innovative/high-tech approaches (bigger risk).
Supporting appropriate uptake of feed products with reduce enteric methane emissions in sheep	Not applicable or suitable for all and further assistance (educational and resources) in order to implement on-farm.	Could be included in Tier 2 as an elective payment for those able to implement on-farm.	Innovative approach to take on.

(f) All Sectors

Measure	Tier 1: Basic Payment	Tier 2: Elective payment	Tier 3/Tier 4: Complementary support
Efficient nutrient management	Should already be applied in basic payment.	Could include precision agriculture to better target nutrient inputs.	Could be included in Tier 3 as part of targeted actions, nature restoration practices and/or innovation support.

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Table 2: Knowledge gaps and barriers to implementation

Measure	Potential barriers towards uptake/implementation
Winter cover	Financial implications, understanding variety suitability, tenancies/land rental (potentially have restricted access/timings on land use), change in behaviour from what they have regularly done before. Knowledge and training, management of weeds, changing weather patterns, narrow post-harvest window in which to establish (especially in Northern regions of Scotland). Also, the overall benefits remain unclear and would likely need to spray off with glyphosate, green bridge for pests/diseases (when not within a mixed system).
Minimum/No Tillage	Suitability of land and soil type, rotation restrictions, tenancies/rental of land, pesticide usage restrictions/legislation, behaviour change, training, suitable equipment, crop suitability, profitability, knowledge and experimenting, cultivation is an important tool for weed control, reduced yield.
Efficient / Reduced use of inorganic fertilisers and lime	Cost of precision application equipment & soil mapping, training for use, reduced yield, lag before soil health recovers.
Efficient / Reduced use of synthetic pesticides	Cost of precision application equipment & soil mapping, training for use, reduced yield, increased risk to production.
Use of N fixing crops	Cost of establishment, lack of knowledge, limited availability of herbicides, difficulty in establishment, roots to market for N-fixing crops, unclear on benefits.
Diversify crop rotation and break crop rotation period (esp. for root crop)	Markets for diversified crops, suitable equipment, lack of knowledge.
Inter-cropping, under-cropping and mixed cropping (e.g. peas and barley) and avoid monoculture	Suitability of land, soils and timings of implementation within rotation, suitable equipment, variety choice, training and experimentation, behaviour change, challenges in harvesting crop, risk of contamination between crops harvested, limitations on end use of crop(s). Knowledge of benefits unclear, limited availability of herbicides.
Arable/ley rotations (transition from arable to arable/livestock mix)	No livestock on farm, unsuitable infrastructure (stock proofing fields/watering points), animal husbandry knowledge required, new roots to market.
Biodiversity cropping and silvo-arable systems	Correct alley width needed for silvo-pastoral, suitable species, difficulty in establishing trees (deer/ hare/ vole) and floral strips, cost of tree maintenance, potential shadow impact on crop development and yield, time-lag before economic benefits derived, impact of tree roots on field drains, lack of knowledge reproduction/roots to market, lack of persistence of floral strips, loss of productive land (particularly due to agro-chemical buffer around in field strips), green-bridge/source of pests, weeds, disease.
Silvo-arable systems	Correct alley width needed for silvo-pastoral, suitable species, cost of tree maintenance, potential shadow impact on crop development and yield, time-lag before economic benefits derived, impact of tree roots on field drains, lack of knowledge reproduction/roots to market.
Diverse sward species content (legumes-herb-grass mixtures) and use of herbal leys	Seed cost, cost, time and emissions from reseeding and ground prep, selective grazing from sheep, interaction with pesticide use, lack of persistence of sward diversity, requirement for sward mixtures of regional provenance.
Regenerative grazing (mob, strip, adaptive multi-paddock grazing) on improved grassland	Time to implement, training and behaviour change in grassland monitoring and understanding, cost of fencing to manage, training of livestock to observe fencing, cost of electric fencing/watering points, complicated to implement, reduced paddock size can limit natural behaviours (e.g. need to consider shelter/shade).
Bird friendly Crop Operations	Knowledge of birds and nesting times, training.

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Silvo-pastures	Suitable species, cost of tree maintenance, potential shadow impact on crop development and yield, risk of tree roots on field drains, difficulty in establishing trees due to grazing livestock, upland system harsh weather can prolong establishment, delay before economic benefits (e.g. fruit/wood).
Arable and Silage/Hay Crop Margins	Loss of yield from land taken out of production, reservoir for pests/weeds/diseases.
Water Margins	Fencing and livestock, alternative watering points required, land taken out of production, reservoir for pests/weeds/diseases.
Retain and Enhance in Field Biodiversity Cropping and Features	Specialist input, knowledge, cost, time, loss of yield from land taken out of production, reservoir for pests, weeds, diseases, difficulty in establishment/lack of persistence.
Enhance existing Hedgerows	Cost of maintenance, labour, training & equipment, availability of trained specialists, loss of productive land, reservoir for pests/weeds/diseases, messy and restricts visibility – farmer seeing into fields but also road users, lack of availability of trees.
Manage Grazed Habitats	Difficulty in achieving correct grazing pressure (risks of both over and under grazing), grazing pressure site specific (one rule doesn't fit all), financial implications of reduced stocking densities/reduced inputs, may not fit with production system.
Retain Traditional Cattle	Knowledge of different breeds, costs associated with change, loss of family lineages and expertise in these.
Summer Hill Cattle Grazing	Not suitable for all hill ground, risks to peatland, labour relocating cattle to check on them.
Introduction of Small-Scale Tree and Shrub Planting	Suitable species, cost of tree maintenance, potential shadow impact on grass growth, risk of tree roots on field drains, difficulty in establishing trees due to grazing livestock, upland system harsh weather can prolong establishment, loss of productive land.
Supporting and incentivising improved beef cattle nutrition	Data availability providing clear guidance, financial implications for new technologies, methods or alternative feeds. Resources needed for implementation of monitoring (training), precision feeding practicalities.
Supporting and incentivising genetic improvement of beef cattle	Data availability that provides focused guidance and advice, financial and educational resources required to implement genetic improvements, time investment required, resources for genetic recording, monitoring & reporting.
Support maintaining and improving beef cattle health	Data availability that provides practical guidance across breeds, resources required to implement as well as monitoring (which will require training), environmental factors (how best align to other management practices).
Supporting appropriate uptake of feed products which reduce enteric methane emissions in beef cattle	Data availability on products (intake requirements, intake frequency, implications on animal health and efficacy of methane reduction potential), resources required for the implementation of monitoring (training), feeding practicalities.
Supporting and incentivising improved dairy cattle nutrition	Data availability providing clear guidance, financial implications for new technologies, methods or alternative feeds. Resources needed for implementation of monitoring (training), precision feeding practicalities.
Support and incentivise genetic improvement of dairy cattle	Data availability that provides focused guidance and advice, financial and educational resources required to implement genetic improvements, time investment required, resources for genetic recording, monitoring & reporting.
Support maintaining and improving dairy cattle health	Data availability that provides practical guidance across breeds, resources required to implement as well as monitoring (which will require training), environmental factors (how best align to other management practices).
Supporting appropriate uptake of feed products with reduce enteric methane emissions in dairy cattle	Data availability on products (intake requirements, intake frequency, implications on animal health and efficacy of methane reduction potential), resources required for the implementation of monitoring (training), feeding practicalities.
Supporting and incentivising improved sheep nutrition	Data availability providing clear guidance, financial implications for new technologies, methods or alternative feeds. Resources needed for implementation of monitoring (training), precision feeding practicalities.
Support and incentivise genetic improvement of sheep	Data availability that provides focused guidance and advice, financial and educational resources required to implement genetic improvements, time investment required, resources for genetic recording, monitoring & reporting.
Support maintaining and improving sheep health	Data availability that provides practical guidance across breeds, resources required to implement as well as monitoring (which will require training), environmental factors (how best align to other management practices).

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Supporting appropriate uptake of feed products with reduce enteric methane emissions in sheep	Data availability on products (intake requirements, intake frequency, implications on animal health and efficacy of methane reduction potential), resources required for the implementation of monitoring (training), feeding practicalities.
Efficient nutrient management	Data availability providing guidance across farm and soil types, resources required for monitoring and record keeping, training, availability and cost of equipment/soil testing, land, soil and crop mix & suitability.

Phase 2: Allocating funding across payment Tiers 1-4

To provide a preliminary indication of the financial costs associated with measures within each tier, economic costs (and GHG reduction potential) associated with each measure were collated from recent Scotland-relevant literature⁴. Abatement potential is based on evidence of carbon mitigations per hectare or per head, rather than the total abatement potential for Scotland as a whole, factoring in proportions of enterprises. Generally speaking, mitigations are expressed in these units, except for a smaller number of research reports which estimate the total mitigation potential of Scotland as a whole (e.g. MACC, 2010 and Martineau et al, 2016⁵). Extrapolating to country-wide mitigation estimates involves complex emissions modelling which is beyond the scope of this work. Challenges associated with estimating the financial implications of agri-reform measures across the tiered framework are explored.

2.1 Abatement potential across agricultural measures

There are many mitigation strategies currently available, with varying abatement potentials and cost effectiveness. To drive progress towards net zero targets within rural businesses there is a need to identify which measures provide high GHG abatement potential at low cost and which can be easily adopted. This section provides an overview of GHG mitigation potential across agri-environmental measures, the economic cost these are likely to incur and the challenges. There is also considerable value in determining which mitigation strategies have the potential to provide multiple benefits (e.g. nature restoration, regulation of flood waters, reducing diffuse pollution). A rapid evidence assessment of research-based data published indicates the agri-reform measures in Table 3 to be the most significant contributions to GHG abatement.

Table 3: Agri-reform measures and their corresponding abatement potential

Measure	Abatement Potential (tCO ₂ e/ha/yr)
Supporting appropriate uptake of feed products with reduce enteric methane emissions in dairy cattle	1.881 tCO ₂ e/ha/yr ⁶
Silvo-arable systems	1.5 tCO ₂ e/ha/yr ⁷
Enhancing existing hedgerows	1.0 tCO ₂ e/ha/yr ⁸
Use of N fixing crops (i.e. grain legumes in grass rotations – forage legumes captured in another measure)	0.553 tCO ₂ e/ha/yr ⁹

⁴ Published journals on Web of Science and reports by ClimateXChange, Climate Change Committee, and SRUC

⁵ Martineau et al, 2016, Effective performance of tools for climate action policy – meta-review of Common Agricultural Policy (CAP) mainstreaming

⁶ Eory et al, 2020, Marginal abatement cost curve for Scottish agriculture

⁷ Perks et al, 2018, Agroforestry in Scotland – potential benefits in a changing climate

⁸ Natural England report on Carbon storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources.

⁹ Eory et al, 2020, Marginal abatement cost curve for Scottish agriculture

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Supporting appropriate uptake of feed products which reduce enteric methane emissions in beef cattle	0.5076 tCO ₂ e/ha/yr ¹⁰
Supporting and incentivising genetic improvement of beef cattle	0.405 tCO ₂ e/ha/yr ¹¹

It was not possible to source an estimated mitigation potential figure for all measures, however, the measures highlighted in Table 3 align relatively well with Scottish Government’s agricultural reform measures, practices outlined in EU’s Common Agricultural Policy and DEFRA’s priorities on land–use changes for carbon sequestration such as agroforestry and improved cattle genetics to achieve Net Zero 2050¹². The adoption of methane suppressing feed products is an area of focus as well with an aim of introducing it to the market in 2025¹³. In a rapid evidence review by Albanito et al (2022), low carbon farming, release of agricultural land, agroforestry and hedges were highlighted as key measures to achieve a Balanced Net Zero Pathway Scenario, targeting livestock diet, health, and soil management¹⁴.

However, given the dominance of Less Favoured Area land in Scotland (85% of agricultural land) and the relevant mitigations for these largely specialist beef and sheep enterprises, top mitigations for Scotland as a whole would expect to also include measures outlined in Table 4. However, it is worth mentioning that the data available to determine abatement potential differs across the different measures due challenges in measuring emissions across different management practices, outlined in Section 2.2.

Table 4: List of measures relevant to dairy, beef, and sheep sector in Scotland.

Measure	Abatement Potential (tCO ₂ e/ha/yr)
Supporting and incentivising improved beef cattle nutrition	0.229
Supporting and incentivising improved sheep nutrition, intensive systems	0.229
Supporting and incentivising improved dairy cattle nutrition	0.125
Support maintaining and improving dairy cattle health	0.125
Supporting appropriate uptake of feed products with reduce enteric methane emissions in sheep	No current evidence published, but mitigation potential expected to be ‘medium’

¹⁰ Eory et al, 2020, Marginal abatement cost curve for Scottish agriculture

¹¹ Eory et al, 2015 – Review and update the UK Agriculture Marginal Abatement Cost Curve to assess the greenhouse gas abatement potential for the 5th carbon budget period and to 2050

¹² DEFRA (2019) Written evidence submitted by the Department for Environment, Food, and Rural Affairs (AZE0038).

¹³ UK Government (2023) Press Release: Further action to cut methane emissions from livestock.

¹⁴ Albanito, F. (2022) Agroecology– a Rapid Evidence Review.

2.2. Challenges and limitations in assessing GHG mitigation potential.

There are significant challenges associated with assessing GHG mitigation potential due to a range of factors, such as the inherent heterogeneity of natural systems, the range of agricultural enterprise types across Scotland, and inconsistencies of data availability across different measures and uncertainties associated with data that is available. There are several challenges underlying the availability of GHG mitigation data across measures, such as;

- Available data is often derived from studies with a range of different spatial and temporal scales, which can result in difficulties making standardised comparisons (e.g., per year vs across implementation cycle, per hectare vs per head livestock, mitigation on output basis vs national mitigation potential).
- Some agri-reform measures are difficult to measure and monitor (e.g. regenerative grazing practices) due to the complexity of these systems, large variability in application, and difficulties in accounting for interactive effects on GHG emissions.
- Data availability ranges across the agri-reform measures and so some datasets are more robust than others or provide greater insight into the associated underlying uncertainties within the available data. Conflicts between data reported can be challenging to unpick without detailed understanding of method and parameters of models used.
- There are practical challenges in collating raw field (or lab based) GHG data, due to financial and time investments required. Due to the nature of GHG fluxes there is often a need for regular sampling to capture peak flux events, which can be time consuming and requires technical expertise to conduct the deployment of gas chambers, collection of samples, analytical procedures, and appropriate interpretation of results.
- GHG fluxes and soil carbon sequestration potential vary temporally and spatially, therefore, require high replication of sample points to provide meaningful representation and statistical robustness of outputs. Therefore, researching GHG fluxes through effective measuring and monitoring over temporal and spatial scales to can be very costly.
- GHG mitigation potential of individual measures is difficult to measure in the field as these management practices are rarely conducted in isolation and there are interactive effects from the mixture of practices applied annually as well as legacy effects from past management.
- Where individual mitigation potentials are estimated, there are challenges when attempting to estimate the combined and cumulative effects from a collection of management practices being applied. In addition, the interactions within food production systems where there is a lack of standardised approaches for quantifying GHG emissions, carbon capture potential and overall environmental sustainability index for a particular product. For example, conversion to organic might reduce a farm's carbon footprint, but due to lower yields may actually increase carbon per unit output. There are also discrepancies in what the unit output should be to best represent 'sustainability' within agricultural practices (E.g. CO₂e, kg, kilo joules, kg/protein etc.)

These challenges lead to difficulties in synthesising datasets to provide end-values that are representative of the different land use types, enterprise types, management practices, landscape characteristics that also encapsulate seasonal and climatic variations across a given area. Therefore, when synthesising GHG data there is a need to understand and take into account, the underlying assumptions and uncertainties associated with reported GHG mitigation data across various published sources in order to make meaningful and appropriate comparisons across different practices.

2.3 Assessing GHG mitigation potential, feasibility, and uptake – Challenges with monitoring progress.

Agri-reform measures were ranked into high, medium, and low mitigation potential and economic costs (Table 5). In addition, an indication of confidence is provided based on evidence available; this includes consideration for the number of research papers published, level of evidence reported within the publication, as well as variability of evidence on mitigation impact (i.e. high variability suggests low scientific evidence or consensus). Some measures proved challenging to find credible scientific evidence of impact. This may reflect the ongoing research and state of complexity in assessing these measures, but a reasonable mitigation impact is expected, including: introduction of small-scale tree and shrub planting; managing of grazed habitats; grass leys in arable rotations; and supporting and incentivising genetic improvement of sheep. It should also be noted that little consolidated evidence on improved nutrition of livestock is readily available, though there is good evidence of specific nutritional interventions for livestock. Other measures had little or no published evidence to support mitigation, and anticipated mitigations would expect to be small, including: efficient/reduced use of synthetic pesticides (<1% of crop emissions); biodiversity cropping (without carbon co-benefits); arable and silage/hay crop margins; and water margins in both grassland and arable fields.

Assessing the economic costs across all measures is equally complex, given the variable evidence available, as well as the range of metrics and parameters used to assess costs. Typically, the economic cost of a measure refers to costs incurred with the establishment and maintenance of a given measure, whereas income foregone and net cost to the farmer are much less available given how dependent they are to each individual context. Economic costs are not consistently measured for direct comparison¹⁵, but important factors to bear in mind when conducting a full assessment of cost, and analysis of cost effectiveness of mitigations, include:

- Establishment cost (sometimes referred to as capital expenditure – Capex)
- Maintenance cost (sometimes referred to as operational expenditure – Opex)
- These averaged together can be shown as an annualised cost.
- Income foregone (to the farmer through implementation, particularly relevant to some biodiversity or habitat related measures below)

¹⁵ Not all MACC reports use similar quantification of cost. Cost-effectiveness is calculated on the relative cost of implementation per unit of carbon abatement, and negative values indicate marginal income instead (Eory et al., 2015). Other MACC reports (Eory et al., 2021) use annualised cost, which should not be directly compared.

- Net cost to farmer (factoring in potential grants available and any productivity improvements).
- The discount rate used in cost calculation and time horizon for implementation of the measure (and in some cases, maintenance of mitigation outcome beyond the intervention).
- The baseline measure/assumption of current practice, which affects the additional costs of implementation.
- Full cost-benefit of measures requiring system changes on farm, or within farming supply chains, e.g. dairy-beef systems.
- Additional cost of financing, where capital is not available up-front.
- Risk factors, such as returns on investment, inflation, market volatility and labour availability.
- Variability of costs across a wide range of system types, sizes, contexts, topography etc.

High-cost measures highlighted in Table 5 include: low/minimum tillage; low emissions manure spreading; use of grain legumes in arable rotations; intercropping/mixed cropping/under-sowing; silvo-pastures. High costs are largely associated with machinery or infrastructural investment required, as well as market and crop value loss in the context of grain legumes in Scotland. Importantly, the table also highlights a number of cost-saving measures, many of which correlate with medium to high mitigation potential. These 'low-hanging fruits' include:

- Efficient / Reduced use of inorganic fertilisers and lime (variable rate application).
- Improving organic [nutrient] planning.
- Shifting autumn manure application to spring.
- Diverse sward species content (legumes-herb-grass mixtures) and use of herbal leys.
- Supporting and incentivising improved beef cattle nutrition.
- Supporting and incentivising genetic improvement of beef cattle.
- Supporting and incentivising improved dairy cattle nutrition.
- Support and incentivise genetic improvement of dairy cattle.
- Support maintaining and improving dairy cattle health.
- Supporting and incentivising improved sheep nutrition - intensive.

Table 5: Evaluation of agri-reform measures on abatement potential, cost, and evidence.

Measure	Abatement potential	Cost	Certainty of evidence
Supporting and incentivising genetic improvement of beef cattle	High	Cost saving	Medium
Efficient / Reduced use of inorganic fertilisers and lime (variable rate application)	Medium	Cost saving	High
Improving organic [nutrient] planning	Medium	Cost saving	High
Shifting autumn manure application to spring	Medium	Cost saving	High
Supporting and incentivising improved dairy cattle nutrition	Medium	Cost saving	High
Support maintaining and improving dairy cattle health	Medium	Cost saving	High
Efficient nutrient management	Medium	Cost saving	High
Supporting appropriate uptake of feed products which reduce enteric methane emissions in beef cattle	High	Medium	High
Supporting appropriate uptake of feed products with reduce enteric methane emissions in dairy cattle	High	Medium	High

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Silvo-arable systems	High	Medium	Medium
Low emissions manure spreading (trailing hose/slurry shoe)	Medium	High	High
Use of N fixing crops (suggest merge with following as grain legumes in grass rotations)	High	High	Medium
Support maintaining and improving sheep health	Medium	Medium	High
Support maintaining and improving beef cattle health	Low	Cost saving	High
Diverse sward species content (legumes-herb-grass mixtures) and use of herbal leys	Medium	Cost saving	Medium
Supporting and incentivising improved beef cattle nutrition	Medium	Cost saving	Medium
Support and incentivise genetic improvement of dairy cattle	Medium	Cost saving	Medium
Enhance existing Hedgerows	Medium	High	Medium
Supporting and incentivising improved sheep nutrition - intensive	Medium	Cost saving	Low
Support and incentivise genetic improvement of sheep	Medium	Low	Low
Winter cover	Medium	Medium	Medium
Diversify crop rotation and break crop rotation period (esp. for root crop)	Medium	Medium	Medium
Supporting appropriate uptake of feed products with reduce enteric methane emissions in sheep	Medium	Medium	Low
Efficient / Reduced use of synthetic pesticides	Low	Cost saving	Low
Supporting and incentivising improved sheep nutrition - extensive	Low	Cost saving	Low
Arable and Silage/Hay Crop Margins	Low	Low	Low
Water Margins in arable fields	Low	Low	Low
Manage Grazed Habitats	Low	Low	Low
Introduction of Small-Scale Tree and Shrub Planting	Low	Low	Low
Water Margins in grassland fields	Low	Medium	Low
Arable/ley rotations (transition from arable to arable/livestock mix)	Low	Medium	Low
Regenerative grazing (mob, strip, adaptive multi-paddock grazing) on improved grassland	Low	Medium	Low
Silvo-pastures	Low	High	Medium
Minimum/No Tillage	Low	High	Medium
Inter-cropping, under-cropping and mixed cropping (e.g. peas and barley) and avoid monoculture	Low	High	Medium
Bird friendly Crop Operations	LD	High	Low
Biodiversity cropping and silvo-arable systems	LD	Medium	Low
Retain Traditional Cattle	LD	LD	Low
Summer Hill Cattle Grazing	LD	LD	Low
Retain and Enhance in Field Biodiversity Cropping and Features	??	??	Low

LD: Lack of data to confidently categorise.

Phase 3: Uptake requirements to reach net zero targets.

It has been reported that there is the potential to reduce emissions by 7.1 Mt CO₂e by 2035 using available cost-effective mitigation strategies across all agricultural emissions, however, this is only 28% of the 25.4 Mt CO₂e reduction needed to achieve the Climate Change Committee's target of 21 Mt CO₂e by 2050, leaving 72% of emission reduction still to be achieved between 2035 and 2050 (excluding emissions and reductions within LULUCF)¹⁶. The Climate Change Committee commented in a recent report that there is "a lack of progress in low carbon farming and productivity measures needed to decarbonise the agriculture sector" and that there are "major risks to delivering the necessary emissions reductions from agriculture and to freeing up land needed for UK-based GHG removals"¹⁷.

¹⁶ Buckingham et al (2023) <https://journal.hep.com.cn/fase/EN/10.15302/J-FASE-2023495>

¹⁷ Climate Change Committee. Progress in Reducing Emissions: 2022 Report to UK Parliament. *Climate Change Committee*, 2022

To determine a realistic pathway to net zero within the agriculture sector, there is a need to translate and extrapolate GHG mitigation potentials across the agri-reform measures into tangible achievable actions. However, as outlined, this is challenging due to inherent complexities that need to be considered, for example challenges associated with quantifying required uptake include;

- The overall priorities among various mitigation strategies are not well-understood.
- The financial optimum can be derived using marginal abatement cost curves, some mitigation options are more difficult to implement due to the initial financial commitments, lack of knowledge or scepticism among farmers, and other factors leading to a low uptake rate.
- How best to categorise farm types.
- How best to amalgamate GHG mitigation potentials across different practices without resulting in additionality and stacking of measures that may lead to an overestimation of GHG mitigation potential.
- What is the baseline from which to assess the impact of management interventions? There is a need to identify the quantity of farms that are already doing these measures to understand the true gap between current activities and requirements to meet net zero targets.
- Stacking and additionality of finances and in particular GHG mitigation potential need to be avoided.
- Interactive effects of different measures are not fully accounted for.
- Some measures are rarely applied in isolation and so may have little effectiveness when applied on their own, therefore should be considered as part of a suite of measures. However, this requires more investigation to assess suitable grouping of measures as well as the cumulative effect on GHG mitigation potential this may have.
- How best to rank or prioritise the impact of different measures across greenhouse gas emissions and the wider impacts on ecosystem health and functionality, as for some measures there may be great biodiversity benefits but contribute less to greenhouse gas mitigation, and visa versa.

In addition to the challenges associated with inherent complexities of quantifying required uptake, there are also several practical barriers that may hinder the uptake of agri-reform measures for GHG mitigation, such as;

- A lack of underlying data/knowledge to provide effective guidance to land managers. This can lead to a lack in confidence in terms of the effectiveness of a particular practice and therefore have increased risk associated with its implementation. Inconsistent evidence – In some cases the scientific research is still novel and perhaps lacking.
- A lack of communication, guidance and advice to provide education/understanding of how best to incorporate/implement new/different practices.

- Risks associated with costs and productivity that management changes and adopting new practices/approaches may have (e.g. loss of crop yield). This could include market volatilities which may lead to reluctance.
- A lack of legislative support and government incentives.
- Limited opportunity to change practices (E.g. tenancy/ownership, lack initial investment costs).
- A reluctance towards changes due to personal opinions and circumstances.

Research and guidance:

The agricultural profile of Scotland is diverse, for example: changes of land classification for agriculture; soil series, topography; and weather. Guidance and research needs to be able to cater for the variances that Scottish farmers face while producing high quality produce. When introducing new management techniques, being able to confidently ensure that they will be effective for all climates and business types is a difficult task. Research and trial sites are carried out throughout Scotland, however, they are restricted by geography, funding and timing. Therefore, the scope of variables for all land types across Scotland cannot be scoped into all trials. This can result in farmers throughout Scotland having to trial innovative management techniques with the risk that they will not work for their land. This is a financial risk for the farm, which many can't afford to make. The scope for improvement and farm management could be great, however, there needs to be relevant research and guidance available for farmers to make informed decisions for their farm.

Financial Investment:

As highlighted, further uptake of GHG mitigation management practices will need to be adopted in order to achieve net zero targets, however, this will come at a financial and emotional cost. To be able to implement new schemes within farms new skills, infrastructure and investment will be required on a sector that is already struggling with rising costs, reduced labour availability and time constraints. Many farms have been operating similar systems successfully for years, gaining good yield, understanding their land and within their means. However, new methods may require learning new skills, having the requirement to use and learn new machinery, at a cost, and in some cases have the requirement to employ additional skill sets to implement new techniques, for example the employment of hedge layers to improve hedgerows. All these attributes would take time to learn, financial implications to implement and the need for labour, which many farms are struggling to find. If these measures are implemented there needs to be a strategy to aid farmers to successfully implement these schemes to not over burden and overload. With the additional impact of extreme weather farmers are needing to make decisions to mitigate against this, which is another area of management for them to incorporate. Many features may be taken from the list of measures, however, financial losses have accrued from weather events and farmers are being cautious to reduce future losses. Moving forward farmers have to make decisions to help the secure the future of their farm.

Knowledge Transfer

Many of the new measures will be unfamiliar for farmers and there needs to be guidance and support in place to aid farmers in venturing into these new farm practices. Currently the future of the farming sector is being negotiated and planned, however, this results in

ambiguity and uncertainty for those who are farming now. The unknown is leading to indecision or delay in action as many are reluctant to invest when they do not know what is coming into legislation in the near future. Information needs to be disseminated in a form to which is useful to farmers. The method of how this is done varies, through meetings, on farm showcase to videos showing the techniques. Farmers need to be given clarity on the future of the sector to be able to make informed decisions, which will suit their business and the aims of the Government.

Farm limitations

Many farmers work under contract, with tenant agreements to industry conditions, which would reduce engagement with the measures laid out within Tier 1 and Tier 2. Having contracts already in place to ensure that produce is supplied following strict rules may hinder the flexibility that some farmers may need to opt into new ventures. For those who are tenants the flexibility to introduce structural changes to the farm may not be an option, therefore, this needs to be accounted for and acknowledged.

Farmer engagement

Furthermore, some farmers are resistant to change. With the constant pressures on farmers, with administrative duties, economics and practicalities of farming, introducing further measures which they need to implement on farm is too much at present for many. Schemes need to be functional, achievable and show that they can make businesses more resilient and profitable for many farmers to spend the time and money investing. There needs to be evidence that new processes and management techniques will help their farm and their business. Putting more pressure and workload onto farmers will not incentivise engagement within this reform.

Conclusion and Recommendations

The Agricultural Reform published by the Scottish Government focuses on sustainable and regenerative agricultural practices as the criteria to deliver support payments for farmers. These measures will form the basis of the Tier 2 Enhanced Payment. Current guidance indicates that from 2026, 50% of basic farm payment will move from Tier 1 into Tier 2. The team completed a three-phase review of the scheme to

- i) analyse the proposed 4-tier scheme design,
- ii) evaluate funding requirements across the proposed scheme design, and
- iii) investigate the scale of uptake required to meet net zero targets.

The analysis of Scottish Government's Agricultural Reform List of Measures reveals a mix of practices already supported by Basic Payment Scheme or easily implemented, and challenging interventions that require additional funding which sit on Tier 2 and above. However, there is a lack of data availability and guidance due to the complexity of these measures as they are dependent on interactions with ecological systems, available equipment, technology, technical knowledge, and financial capacity. While the report lists the top measures based on their GHG abatement potential, data gaps mean not all measures are directly comparable. Therefore, it is crucial to understand the underlying assumptions and uncertainties for more accurate and meaningful comparisons. While silvo-arable systems and hedgerows show significant abatement potential, livestock measures (feed products reducing methane emissions in dairy, beef, and genetic

improvement of beef cattle) were salient in the context of Scotland with its large beef and sheep enterprises.

An evaluation of the abatement potential, economic cost, and quality of evidence reveal certain measures are low hanging fruits, such as reducing synthetic inputs, diverse swards and better livestock nutrition as well as genetics. Nevertheless, barriers of uptake will remain a challenge and must be addressed to ensure a successful roll out of The Agricultural Reform framework. Limited trials of these measures in Scotland increase the perceived risk of its implementation. Combined with the upfront financial cost and initial yield reduction amid tough market conditions, farmer resistance to this scheme can be expected.

RECOMMENDATIONS

1. More monitoring of on-farm activities

Further implementation of evidence-driven mitigation approaches is needed if net zero targets are to be achieved. To better grasp the scale of uptake required to make significant contributions to net-zero there needs to be further data captured in relation to current on-farm activities in relation to the agri-reform measures and management practices contributing to GHG mitigation. If the current state of uptake is better understood, then more targeted efforts can be made in relation to developing on-farm greenhouse gas mitigation and removal strategies across different land uses.

2. Further research into GHG emissions associated with agri-reform measures.

There is currently little quantitative evidence on the long-term effectiveness of GHG removal strategies outlined, this is most likely due to the risk of implementing a potentially high cost, high uncertainty strategy. Therefore, further research is needed to evaluate;

- o Efficacy of each strategy for removing atmospheric GHGs
- o Longevity of effectiveness
- o Potential negative side-effects, knock-on effects and trade offs
- o Financial investments required

3. Addressing barriers to uptake and supporting the adoption of new/different practices across farm types

There is a need to better understand barriers to uptake in order to develop and implement strategies to drive further uptake of GHG mitigation approaches. This can be achieved through further education and consultancy services. Financial support from government and associated agencies will likely be needed to encourage and assist with the adoption of new/different management practices, particularly where additional resources or new technologies are required.

Further research, guidance, and technical capacity development support should be implemented in tandem to ensure schemes are fit for purpose and successful in delivering resilient, sustained low carbon farming.

Appendix 1: The Agricultural Reform Measures

Full description of each measure included in the Agricultural Reform programme Taken from <https://www.ruralpayments.org/topics/agricultural-reform-programme/arp-list-of-measures/>

Type of Land:	Habitat	Outcomes	Package	Measure	Descriptor
In Field - Cultivated Soils	Arable Crops - including fodder crops; Grassland - improved, Grassland - temporary	Reducing Soil Greenhouse Gas (GHG) emissions; Increasing soil carbon/organic matter content; Increasing resilience to weather events; Improving soil nutrient content; Reducing diffuse pollution; Improving water and air quality; Improving soil water retention and flow; Improving soil biodiversity; Removing drivers for biodiversity loss	Continuous Soil Cover	Winter cover	Retain stubbles from a combinable crop over the winter. Stubble area to be left ungrazed, unsprayed, and undisturbed before 1 March following harvest. Retaining the stubble helps to protect the soil, retain organic matter, and will improve mitigation and adaptation to the effects of climate change. Leaving stubble until early spring will also allow a variety of arable plants to develop, providing food and cover for insects, birds and small mammals.
				Minimum/No Tillage	Minimise soil disturbance, avoid inversion and avoid deep ploughing (if no major compaction or large weed burden) by using a direct drill, discs, or different machinery. This will keep soil structure and its biodiversity, avoid organic matter oxidation and disruption of soil biodiversity. Minimum / no tillage will not be suitable for all soil types or crops, and may be affected by other constraints such as compaction, weed burden etc.
			Efficient / Reduced use of synthetic inputs	Efficient / Reduced use of inorganic fertilisers and lime	Use your soil analysis recommendation and crop agronomic advice to apply only where and as little as necessary or extenuating circumstances require a dispensation. Apply inorganic fertilisers and lime as per soil analysis and crop requirement with variable rate using precision spreading based on mapping and crop monitoring where available. Implementation could be extended by increase the use of legumes in the rotation, use green manure, use animal manure or livestock grazing, compost and digestate. To protect soil health and water quality and protect habitat conditions for pollinating insects, wild birds and small mammals.
				Efficient / Reduced use of synthetic pesticides	Using an Integrated Management approach, you will only apply synthetic pesticides if economic threshold of pest/disease is reached, or extenuating circumstances require a dispensation. To protect soil health and water quality and protect habitat conditions for pollinating insects, wild birds and small mammals. Implementation could be further extended by use of GPS enabled technology, where available, to apply variable rates.
				Use of N fixing crops	Add legumes such as peas or field beans into the cropping rotation, and other appropriate catch/cover/green manure/soil improver crops including pasture legumes. To improve soil health and water quality and improve habitat conditions for pollinating insects, wild birds and small mammals.
			Crop Diversity - arable	Diversify crop rotation and break crop rotation	Use a number of different crops in an arable rotation depending on soil type and land capability e.g. oilseed rape, peas, beans, vegetables, potatoes, linseed, oats, forage brassica, forage maize, buckwheat. A varied crop rotation can enhance biodiversity, improve soil organic matter and climate impact resilience. Soil erosion is minimised, pest and disease burdens are reduced. Especially, leave a longer break between soil

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				period (esp. for root crop)	damaging root crops to improve soil recovery (ex: aim for 8 years for potatoes). To improve soil health and water quality and improve habitat conditions for pollinating insects, wild birds and small mammals.
				Inter-cropping, under-cropping and mixed cropping (e.g. peas and barley) and avoid monoculture	To avoid monocultures and improve within field species diversity, plant several crops together (mixed cropping ex: peas and barley, to improve protein content of silage in winter feed and decrease the need for purchased protein), undersow cash crops with undercrop (ex: using clover for N fixing, pest protection and outcompete weeds or grass for low input winter grazing), inter-crop cash crop with flowering mix for Integrated Pest Management (IPM) or with any companion crop that can create synergies and improve yield. To improve soil health and water quality and improve habitat conditions for pollinating insects, wild birds and small mammals.
				Arable/ley rotations (transition from arable to arable/livestock mix)	Add grass or fodder crops into the cropping rotation to allow introduction of grazing animals on arable land. Can also include use of livestock to graze winter cereals to reduce reliance on synthetic inputs. To improve soil health and water quality and improve habitat conditions for pollinating insects, wild birds and small mammals.
				Biodiversity cropping and silvo-arable systems	Provision of Pollinator or Bird friendly crops with beetle banks, bird covers, conservation headlands, and field margins. To improve soil health and water quality and improve habitat conditions for pollinating insects, wild birds and small mammals.
				Silvo-arable systems	Plant trees at suitable interval for machinery in arable field to create silvo-arable systems, in order to improve carbon sequestration, minimise soil erosion, improve drainage, support more biodiversity. Species for coppicing, fruits, nuts or timber can provide marketable products will also improve profitability. To improve soil health and water quality and improve habitat conditions for pollinating insects, wild birds and small mammals.
			Crop Diversity - grassland	Diverse sward species content (legumes-herb-grass mixtures) and use of herbal leys	Attain species diversity in existing rotational grass swards by over seeding or reseeding with diverse species grass mix; including drought tolerant or tussock forming grasses, deep rooting species, herbs and legumes. Along with ryegrass, use timothy, fescues, cocksfoot and herbal leys in rotational grassland (including species like chicory, yarrow, plantain, sainfoin, red/white/sweet/alsike clovers, birdfoot trefoil, burnet). To improve soil health and improve habitat conditions for pollinating insects, wild birds and small mammals.
				Regenerative grazing (mob, strip, adaptive multi-paddock)	Regenerative grazing is the practice of building soil health by managing livestock on grazed areas. It is characterised by: frequent rotation and long resting time/recovery periods for paddocks. Regenerative grazing allows the sward to grow high, to ensure grasses and plants flower and seed. This encourages regrowth and development of strong plant and root systems, which also improves soil microbiology and function.

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				grazing) on improved grassland	Appropriate management for grazed habitats requires minimum rest periods (at least 30-45 days) depending on type of sward.
				Bird friendly Crop Operations	Avoiding field operations at key times, will reduce the risk of damage/disturbance to key waders, corn bunting, corncrake, and their nests. Avoiding cultivation operations where target ground nesting birds are present. Cutting hay, silage, or arable crop in a wildlife-friendly manner (avoiding cutting towards the centre) and leaving a 2m margin around the field to reduce the risk of injury to vulnerable bird species such as corncrake, and waders sheltering in the crop. Only for adoption in fields where nesting waders, corncrake and corn bunting identified during biodiversity audit. An appropriate cutting date to preserve nests must be adopted according to the species being targeted. Can be packaged with other Arable and Silage/Hay Crop Margin measures. Implementation could be extended for corncrake where appropriate to provide suitable early cover by excluding grazing livestock from existing corncrake cover habitat within a whole field during the full growing season and not cutting the sward. From 1 October, the field must be grazed down to remove thatch. Key sites for this measure identified during biodiversity audit within Corncrake target areas.
				Silvo-pastures	Aim is to integrate trees and shrubs into an area of grass crop to benefit biodiversity, carbon sequestration, climate change adaptation, soil health, and livestock health. Trees should be planted in a manner that works with intended cropping or grazing management. During the establishment period (five years), trees will need to be protected from grazing by domestic livestock and wild animals. Suitable tree pruning and management will be needed until the trees are established. Maintaining management, including pruning, will enable both tree establishment and pasture sward to thrive together.
In Field - Margins and Uncultivated Features	Arable crops - including fodder crops; Grassland - improved; Grassland - semi improved; Grassland - Unimproved and	Reducing Soil GHG emissions; Increasing soil carbon/organic matter content and vegetation carbon content; Increasing resilience to weather events; Reducing diffuse pollution; Improving water and air quality;	Retain and Enhance Field Margins and Permanent Habitat Margins	Arable and Silage/Hay Crop Margins	Leave uncropped margins (2m minimum). Increasing the width, structure diversity and species diversity while preventing damage (soil damage, spray drift etc) will improve outcome. Aim for connectivity between field margins and with other semi-natural habitats such as patches of woodland, hedges, water margins, unsprayed road verges. Provides breeding, feeding and cover for farmland birds, insects, pollinators. Remove Invasive Non-Native Species where they are invading the habitat.
				Water Margins	Manage existing fenced and unfenced water margins and buffer strips. Cut or grazed annually to maintain species and structure diversity. If wider than 6m, grazing is possible. To improve water quality, protect ponds and freshwater habitats to benefit insects, fish, and amphibians and create river corridors. Implementation could be extended by unfenced water margins fenced off to exclude stock. Min 6m margins depending on water course width (12m adjacent to still water). Manage to increase diversity of species and structure, as well as connectivity. To improve water quality, protect ponds and freshwater habitats to benefit insects, fish, and amphibians and create river corridors.

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<p>Species Rich Grassland; Water; Wetland; Woodland; Scrub; Heath / Moorland; Bog; Coastal dune/marsh</p>	<p>Improving soil water retention and flow; Improving nature networks; Improving habitat connectivity; Improving soil biodiversity; Removing drivers for biodiversity loss</p>	<p>Retain and Enhance In Field Biodiversity Cropping and Features</p>	<p>Reduce tracking, supplementary feed sites rare and temporary. No pesticides, no fertilisers in existing field margins and biodiversity in-field features. Buffer zone around in field trees.</p> <p>Converting Arable at Risk of Erosion or Flooding to Low-input Grassland – The aim of this measure is to protect water quality and benefit wildlife by converting areas within arable fields which are prone to flooding, run-off and / or soil erosion, to low-input grassland. This will provide year-round cover, which will increase soil organic matter, improve soil structure, reduce surface run-off, and protect against soil erosion and the subsequent risk of water pollution. Flowering plants within the grass will also benefit wildlife. The area is sown with a low productivity grass mix to establish a new sward and the mix must include at least four flowering species to benefit pollinating insects.</p> <p>Management of Buffer strips adjacent to lowland bog/peatland and wetland – This measure support the management of bogs and wetlands by increasing the water levels, creating an effective buffer area of longer vegetation to intercept runoff, therefore, reducing nutrient inputs on land immediately adjacent to, and into the bog or fen. The buffer strip should be a minimum of 10m wide. It may need to be wider depending on the gradient, soil type and management of the surrounding land. Ideally, it should be created by erecting temporary electric fencing or stock fencing to exclude stock. The buffer area will require a period of grazing each year to manage the habitat. Create small plots of a range of biodiversity crops and features.</p> <p>Beetle banks – These are grassy mounds of at least 2m wide cutting across an arable field, providing permanent cover for beetles and other beneficial insects. They are typically seeded with native grasses such as fescues and bents and include tussock forming species such as cocksfoot and timothy. The addition of flowering herbs will help support pest predators such as hoverflies and parasitic wasps and other pollinators. They can also prevent soil erosion and run off. They need regular cutting to help establishment the 1st year and prevent weed overtaking but once established only require to be cut on a 3–5 years rotation to keep providing a diversity of structure.</p> <p>Wild bird covers – These are a mix of specific crops which will provide food and shelter for wild birds and their chicks. They will include a mix of seed bearing crops (linseed, brassica, sunflowers, quinoa), flowering plants to attract insects and their larvae (legumes, phacelia, yarrow, buckwheat), and annual cereals (rye, oats, triticale, barley). Placed near woodlands, tussocky grass patches or hedges, they can provide resources for 2–3 years depending on seed mix. Cannot be sprayed, grazed or cultivated before the 1st March following the year of establishment.</p> <p>Forage brassicas for wild birds – such as turnips, kale, rape and swedes provide a good habitat for a wide range of wildlife if left unharvested, particularly food and cover for wintering farmland birds. Some weeds will also be beneficial, such as charlock, fat-hen, knot grass and redshank. The patches or strips must be at least 6m and need to be under low input management, and not harvested, grazed, sprayed or ploughed down before the 1st of March.</p>
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					<p>Pollinator strips and margins – Within-field strips and margins specifically planted to support pollinators will include a wide range of flowering plants, with different colours and shapes, flowering at different time of the year. They will provide nectar and pollen for beneficial invertebrates as well as egg laying sites and feeding sites for their larvae. They can also include some patches of sunny bare ground and will benefit from being located in full sun, and connected to other habitats such as woodland patches, watercourses, hedges, or flowering road verges. They need to be cut to help establishment and maintenance but cannot be sprayed (unless using spot treatment for weeds and INNS).</p> <p>Species diverse grass strips and margins. Grass strips located within or at the edges and corners of arable fields provide important cover and food for birds and small mammals, as well as flowers for pollinating insects. They can also help improve water quality by preventing soil erosion, intercepting surface water run-off and improving soil structure. Wet corners and patches, left uncultivated can provide habitat for insects and birds. Grass strips are also important for connecting habitats. 3m wide minimum, they will also have added benefits if located next to a hedge, line of trees, unsprayed road verges, dykes or any other linear feature. Seeded with diverse native grass seeds such as timothy, cocksfoot, fescues and bents, they will require cutting once a year, to maintain species and structure diversities.</p>
				Enhance existing Hedgerows	<p>Allow hedge to grow to minimum 1.5m height and width and maintain its 2m GAEC margins, Plant 10% of gaps larger than 5m. Leave hedgerow trees to reach maturity and full height every 50–100m. Implementation could be extended by allowing hedge to grow beyond 1.5m height and width and leave hedgerows trees to reach maturity every 50–100m. Widen the margin to minimum 4m on one side. Trimmed once every 2 years in winter. Introduce native trees and shrubs and plant all gaps larger than 5m. Implementation could be further extended by allowing hedge to grow beyond 3m height and width and leave hedgerows trees to reach maturity every 50–100m. Widen the margin to minimum 4m on both sides where practicable. Fence grassland hedge margins. Trimmed once every 3–5 years in winter. Introduce native trees and shrubs and plant all gaps larger than 5m. Connect hedgerows across the farm.</p>
Uncultivated Permanent Habitats	Arable crops – including fodder crops; Grassland – improved; Grassland – semi improved; Grassland –	Reducing Soil GHG emissions; Increasing soil organic matter and carbon content, and vegetation carbon content; Increasing resilience to weather events; Reducing diffuse	Restore and Manage Existing Nature Rich Habitats	Manage Grazed Habitats	<p>Measure covers a range of grazed habitats including, species-rich grassland, wetland, saltmarsh, habitat mosaic, wood pasture, floodplain, heaths, peatland, moorland etc. Delivered through appropriate grazing management assessed in line with Biodiversity Audit condition assessment criteria for individual habitat types. Improving habitat structure and species diversity and preventing damage will improve outcomes. Improve plant species diversity over time by adopting grazing regimes to promote flowering and seeding of plants with rank vegetation grazed off at the end of the growing season. Overall annual grazing pressure in line with indicative levels for habitat types. Can include seasonally excluding livestock to avoid damage to some sensitive habitats and ground nesting birds (Key waders, corn bunting and corncrake) during the bird nesting season, achieve habitat structure and allow flowering and seeding. No additional inputs of fertiliser/manure. Supplementary feeding managed to avoid damaging sensitive habitats, particularly species rich or wetland habitats. Control of</p>

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	Unimproved and Species Rich Grassland; Water; Wetland; Woodland; Scrub; Heath/Moorland; Bog/Peatland; Coastal dune/marsh.	pollution; Improving water and air quality; Improving soil water retention and flow; Improving nature networks; Improving habitat connectivity; Improving soil biodiversity; Removing drivers for biodiversity loss.			invasive plants and injurious weeds by spot treatment or manual methods where required. Prevention of damage through poaching, erosion, overgrazing and undergrazing. Allow re-wetting of areas where required. Could be combined with GPS collar managed grazing. This is a generic measure designed to support grazing to benefit a wide range of species depending on the target habitat and species identified in the biodiversity audit, including Waders, Pollinators, Farmland Birds, Insects/Beetles, Mammals, Protected Geese, Raptors, Corncrake, Bats, Corbunting, Black grouse. Cattle grazing helps support a more diverse range of habitats. Traditional or native breeds are better adapted to graze land with coarser vegetation and wetter conditions. Cattle graze less selectively than sheep and support a more diverse habitat. The measure will improve the quality of moorlands habitat by grazing with cattle during the summer. Cattle graze less selectively than sheep and support a more diverse habitat. Each bovine grazed on the hill will benefit 20 hectares of moorland. This measure is eligible only when packaged with Manage grazed habitats measure.
				Introduction of Small-Scale Tree and Shrub Planting	Aim: Integrate small areas of native trees and shrubs into areas of natural habitat to benefit biodiversity by increasing native species diversity, providing shelter and shade to livestock, carbon sequestration and climate change adaptation. Areas suitable for planting as listed in biodiversity audit may include: unimproved grassland (excluding species rich grassland); semi-improved grassland; species-poor rush pasture; and existing woodland. Further assessment will be required to ensure natural habitats benefit from the additional planting. During the establishment period (five years), trees will need to be protected, weed growth managed and trees protected from grazing by domestic livestock and wild herbivores.
Beef sector			Improving beef cattle nutrition	Supporting and incentivising improved beef cattle nutrition Evidence shows that improved forage quality and digestibility can improve livestock productivity and therefore lower the GHG emission intensity of livestock production. Measuring, planning, and nutrition management is proven to lead to positive outcomes for livestock, GHG emissions and wider sustainability issues. This measure could include actions to require producers to show awareness of diet composition and the nutritional requirements of the herd, or to demonstrate that forage analysis is being undertaken to inform nutrition planning and improving feed quality. Activity in this area will vary across farm type, location, and production system. Suggested areas of action, where appropriate: Nutritional planning and related actions, Grazing management planning, Sward analysis, Implement mineral and trace element supplementation plan for herd.	
			Improving beef cattle breeding	Supporting and incentivising genetic improvement of beef cattle Informed breeding decisions can accelerate the genetic gains achievable across each generation of livestock, which can lead to efficiency improvements. An increased uptake of genetic improvement which improve livestock efficiency will lead to reduced GHG emissions intensity. The industry-led Beef Sector Strategy 2030 cites the ambition of the industry to make the most of breeding decisions in order for the sector to minimise emissions. Actions could require breeding planning using Estimated Breeding Values as well as potentially supporting the use of more advanced genomic tools. This could include the use breeding indexes which support the sector in moving in the direction of reduced emissions intensity.	

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			Suggested areas of action, where appropriate: Herd breeding plan and related actions, Cull and replacement policy, Herd benchmarking, Use of estimated breeding indexes (EBVs), Use of advanced practices such as genotype profiling, Shifting to lower emissions intensity breeding goals.
	Improving beef cattle health	Support maintaining and improving beef cattle health	Improving herd health will lead to improvements in production efficiency, together they can lower greenhouse gas emissions per Kg of output. Healthier animals are more productive, require less veterinary intervention and have better welfare than their under-performing counterparts. Actions could range from acting on herd health plans to implementing verifiable control and prevention measures. Suggested areas of action, where appropriate: Herd health planning and related actions, Herd health monitoring and diagnosis, Implementing biosecurity policy, Vaccine use, Prevention and control planning, and related actions.
	Methane reduction	Supporting appropriate uptake of feed products which reduce enteric methane emissions in beef cattle	Methane suppressing feed products are natural or synthetic compounds added to or included in animals' diets which lead to less methane being produced whilst the animal is digesting the feed. This is an evolving landscape with increasing evidence emerging demonstrating the potential of feed materials in reducing enteric methane emissions, and a range of products being evaluated and developed. In line with emissions reduction ambitions there may be support where appropriate products are being used in livestock production systems. The Scottish Government recently held a Call for Evidence alongside DEFRA, Northern Ireland Department of Agriculture, Environment and Rural Affairs (DAERA) and Welsh Government and will continue to explore options to incorporate on-farm activity in this area in to future support measures. Suggested areas of action, where appropriate: Uptake of methanogenesis inhibitors, Uptake of other appropriate methane reducing feed materials.
Dairy Sector	Improving dairy cattle nutrition	Supporting and incentivising improved dairy cattle nutrition	Evidence shows that improved forage quality and digestibility can improve livestock productivity and therefore lower the GHG emission intensity of livestock production. This measure could include actions to require producers to show awareness of diet composition and the nutritional requirements of the herd, or to demonstrate that forage analysis is being undertaken to inform nutrition planning and improving feed quality. Suggested areas of action, where appropriate: Nutritional planning – housed and grazing, Grazing management planning, Sward analysis, Implement mineral and trace element supplementation plan for herd, Precision feeding.
	Improving dairy cattle breeding	Support and incentivise genetic improvement of dairy cattle	Informed breeding decisions can accelerate the genetic gains achievable across each generation of livestock, which can lead to efficiency improvements. The dairy sector has developed genetic indexes which reflect the role of genetic improvement in improving the environmental efficiency of milk production. There is potential for these genetic indexes to be used to demonstrate progress toward greater environmental efficiency on Scottish dairy farms. The use of sexed semen in dairy cow insemination has also been cited as a practice which can result in greater environmental efficiency. Actions could require breeding planning which recognises the importance of breeding decisions which improve the environmental efficiency of milk production by incorporating appropriate genetic indexes, and appropriate utilisation of sexed semen on-farm as an action arising from an appropriately implemented breeding plan.

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			Suggested areas of action, where appropriate: Herd breeding plan and related actions, Cull and replacement policy, Herd benchmarking, Use of estimated breeding indexes (EBVs), Use of advanced practices such as genotype profiling, Shifting to lower emission intensity breeding goals
	Improving dairy cattle health	Support maintaining and improving dairy cattle health	Improving herd health will lead to improvements in production efficiency, together they can lower greenhouse gas emissions per Kg of output. Healthier animals are more productive, require less veterinary intervention and have better welfare than their under-performing counterparts. Actions could range from acting on herd health plans to implementing verifiable control and prevention measures. Suggested areas of action, where appropriate: Herd health planning and related actions, Health herd monitoring and diagnosis, Implementing biosecurity policy, Vaccine use, Prevention and control planning and related actions.
	Methane reduction	Supporting appropriate uptake of feed products with reduce enteric methane emissions in dairy cattle	Methane suppressing feed products are natural or synthetic compounds added to or included in animals' diets which lead to less methane being produced whilst the animal is digesting the feed. This is an evolving landscape with increasing evidence demonstrating the potential of feed materials in reducing enteric methane emissions, and a range of products being evaluated and developed. In line with emissions reduction ambitions there may be support where appropriate products are being used in livestock production systems. The Scottish Government recently held a Call for Evidence alongside DEFRA, NI DAERA and Welsh Government and will continue to explore options to incorporate on-farm activity in this area in to future support measures. Suggested areas of action, where appropriate: Uptake of methanogenesis inhibitors, Uptake of other appropriate methane reducing feed materials.
Sheep Sector	Improving sheep nutrition	Supporting and incentivising improved sheep nutrition	Evidence shows that improved forage quality and digestibility can improve livestock productivity and therefore lower the GHG emission intensity of livestock production. Measuring, planning, and nutrition management is proven to lead to positive outcomes for livestock, GHG emissions and wider sustainability issues. This measure could include actions to require producers to show awareness of diet composition and the nutritional requirements of the flock, or to demonstrate that forage analysis is being undertaken to inform nutrition planning and improving feed quality. Activity in this area will vary across farm type, location, and production system. Suggested areas of action, where appropriate: Nutritional planning and related actions, Grazing management planning, Sward analysis, Implement mineral and trace element supplementation plan for herd.
	Improving sheep breeding	Support and incentivise genetic improvement of sheep	Informed breeding decisions can accelerate the genetic gains achievable across each generation of livestock, which can lead to efficiency improvements. An increased uptake of genetic improvement which improve livestock efficiency will lead can lead to reduced GHG emissions intensity. Actions could require breeding planning and use of tools which support the sector in moving in the direction of reduced emissions

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			intensity breeding. Suggested areas of action, where appropriate: Flock breeding plan and related actions, Cull and replacement policy, Flock benchmarking, Use of estimated breeding indexes (EBVs), Use of genomic breeding indexes.
	Improving sheep health	Support maintaining and improving sheep health	Improving flock health will lead to improvements in production efficiency, together they can lower greenhouse gas emissions per Kg of output. Healthier animals are more productive, require less veterinary intervention and have better welfare than their under-performing counterparts. Actions could range from acting on flock health plans to implementing verifiable control and prevention measures. Suggested areas of action, where appropriate: Flock health planning and related actions, Flock health monitoring and diagnosis, Implementing biosecurity policy, Vaccine use, Disease prevention and control planning, and related actions.
	Methane reduction	Supporting appropriate uptake of feed products with reduce enteric methane emissions in sheep	Methane suppressing feed products are natural or synthetic compounds added to or included in animals' diets which lead to less methane being produced whilst the animal is digesting the feed. This is an evolving landscape with increasing evidence emerging demonstrating the potential of feed materials in reducing enteric methane emissions, and a range of products being evaluated and developed. In line with emissions reduction ambitions there may be support where appropriate products are being used in livestock production systems. The Scottish Government recently held a Call for Evidence alongside DEFRA, NI DAERA and Welsh Government and will continue to explore options to incorporate on-farm activity in this area in to future support measures. Suggested areas of action, where appropriate: Uptake of methanogenesis inhibitors, Uptake of other appropriate methane reducing feed materials.
All Sectors	Nutrient management	Efficient nutrient management	Organic manures applied to agricultural land are valuable sources of organic matter and plant nutrients. Careful storage, sufficient capacity and precise application to land allows their nutrient value to be used for the benefit of crops and soils, and significant reduction in the use of inorganic fertilisers. Regular soil tests for pH and nutrient values provide important details for the farm nutrient budget, as does taking into account previous cropping rotations. Equally important is the analysis of slurry, farmyard manures and other organic materials applied to land to know the actual NPK value, rather than relying on standard "book" values. Whilst applying nutrients to match crop requirements helps to improve uptake, consideration to application methods should also be made. The National Test Programme Preparing for Sustainable Farming scheme is currently trialling support for soil sampling to enable field mapping and soil carbon measurement. Suggested areas of action where appropriate, and future measures with potential, include: Covered slurry stores, Anaerobic digestion, Variable rate nitrogen and lime, Low emission spreading, Soil pH management, Urease and nitrification Inhibitors, Slurry acidification

Appendix 2: The proposed 4-Tier payment framework

Full description of the proposed 4-Tier payment scheme. Taken from <https://www.gov.scot/publications/delivering-vision-scottish-agriculture-proposals-new-agriculture-bill/pages/4/>

Tier 1	Base Level Direct Payment
<p>Proposed as a Base Level Direct Payment to support farmers and crofters engaged in food production and land management. This could be viewed as an income support payment for farmers and crofters and will be 'conditional' on essential standards being met to ensure appropriate activity, climate, biodiversity and business efficiency outcomes. Support could be 'conditional' on meeting agreed 'eligibility criteria' such as active farming criteria, a 'Whole Farm Plan', Cross Compliance Regulations and Greening measures. The whole farm plan could include requirements such as a, 'Fair Work Declaration', 'Animal Health and Welfare Declaration', 'Business plan' 'Equality Duty Declaration' including opportunities for women, 'Climate, Environmental, and Nature Declarations', 'Land Management Plans', and 'Carbon, Soil and Biodiversity Audit Declarations'. The purpose of the Whole Farm Plan is to ensure farm and croft activities form the underpinning basic level of sustainability and resilience required for all businesses in receipt of public support</p>	
Tier 2	Enhanced Level Direct Payment
<p>Proposed as the Enhanced Level Direct Payment which follows on from the Base Level Direct Payment. It goes a step further than the 'conditional' measures and offers 'additional' measures to deliver outcomes relating to efficiencies, reducing greenhouse gas emissions and nature restoration and enhancement. This proposal will support producers in being more efficient, incentivise sustainable and regenerative farming practices and improve business resilience.</p>	
Tier 3	Elective Payment
<p>Proposed as the Elective Payment, which follows on from the Enhanced Direct Payment and focusses on targeted measures for nature restoration, innovation support and supply chain support. The Elective Payments would be wide ranging and, where relevant, location specific to ensure thriving rural communities. This will support those in the industry to gain or maintain knowledge and skills required to manage land sustainably, such as targeted support for particular species or habitats, support conversion to alternative forms of agriculture such as organic production and encourage innovation. Support mechanisms developed under this tier could support individuals, co-operatives, or groups involved in delivering targeted outcomes who are not necessarily recipients of support under tiers 1 and 2.</p>	
Tier 4	Complementary Support
<p>Proposed as complementary to Tiers 1, 2, and 3. We propose this to enable the delivery of continuous professional development (CPD), advisory services; support for tree planting, woodland management and associated supply chain support; peatland restoration and management; the agricultural transformation fund; support for areas of natural constraint; and could provide for voluntary coupled support for beef and sheep</p>	

sectors. Support mechanisms developed under this tier could support individuals or groups involved in delivering targeted outcomes who are not necessarily recipients of support under tiers 1, 2 or 3.

Appendix 3: Full table of mitigation and cost estimates, with justification

Measure	Abatement potential	Cost	Certainty of evidence	Notes
Winter cover	Medium	Medium	Medium	
Minimum/No Tillage	Low	High	Medium	Variable and mixed results given impact through soil carbon
Efficient / Reduced use of inorganic fertilisers and lime (variable rate application)	Medium	Cost saving	High	Used variable rate application data
Improving organic [nutrient] planning	Medium	Cost saving	High	
Low emissions manure spreading (trailing hose/slurry shoe)	Medium	High	High	Used trailing hose/slurry shoe figures. Injector has higher mitigation, but lower applicability across Scotland
Shifting autumn manure application to spring	Medium	Cost saving	High	
Efficient / Reduced use of synthetic pesticides	Low	Cost saving	Low	Pesticides <1% emissions, little research attention for emissions
Use of N fixing crops (suggest merge with following as grain legumes in grass rotations)	High	High	Medium	Already covered in grain and forage legume measures elsewhere
Diversify crop rotation and break crop rotation period (esp. for root crop)	Medium	Medium	Medium	Evidence uncertain, potential benefits to soil carbon through some break crops (e.g. hemp), and main benefits with legumes (captured elsewhere)
Inter-cropping, under-cropping and mixed cropping (e.g. peas and barley) and avoid monoculture	Low	High	Medium	Practicalities and markets make this challenging
Arable/ley rotations (transition from arable to arable/livestock mix)	Low	Medium	Low	Figures not included in the MACC as baseline data not available
Biodiversity cropping and silvo-arable systems	??	Medium	Low	Measures too broad and vague to find specific evidence
Silvo-arable systems	High	Medium	Medium	
Diverse sward species content (legumes-herb-grass mixtures) and use of herbal leys	Medium	Cost saving	Medium	
Regenerative grazing (mob, strip, adaptive multi-paddock grazing) on improved grassland	Low	Medium	Low	No definitive figures published and results very varied depending on grassland productivity and grazing intensity
Bird friendly Crop Operations	??	High	??	No evidence of mitigation potential
Silvo-pastures	Low	High	Medium	Performance varies significantly on land quality
Arable and Silage/Hay Crop Margins	Low	Low	Low	Little evidence on mitigation
Water Margins in grassland fields	Low	Medium	Low	Little evidence on mitigation
Water Margins in arable fields	Low	Low	Low	Little evidence on mitigation
Retain and Enhance in Field Biodiversity Cropping and Features	??	??	Low	No evidence of mitigation potential
Enhance existing Hedgerows	Medium	High	Medium	
Manage Grazed Habitats	Low	Low	Low	Measures too broad and vague to find specific evidence
Retain Traditional Cattle	??	??	??	Question logic on this - awaiting feedback from livestock expert
Summer Hill Cattle Grazing	??	??	??	Question logic on this - awaiting feedback from livestock expert
Introduction of Small-Scale Tree and Shrub Planting	Low	Low	Low	No published evidence currently on mitigation potential
Supporting and incentivising improved beef cattle nutrition	Medium	Cost saving	Medium	Few definitive figures on nutrition as a whole, more evidence on particular forages
Supporting and incentivising genetic improvement of beef cattle	High	Cost saving	Medium	Research and data required. There is lack of data on genetics and abatement potential
Support maintaining and improving beef cattle health	Low	Cost saving	High	
Supporting appropriate uptake of feed products which reduce enteric methane emissions in beef cattle	High	Medium	High	Practicalities of implementation challenging

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Supporting and incentivising improved dairy cattle nutrition	Medium	Cost saving	High	Used sexed semen figures, nothing published found for breeding more generally
Support and incentivise genetic improvement of dairy cattle	Medium	Cost saving	Medium	
Support maintaining and improving dairy cattle health	Medium	Cost saving	High	
Supporting appropriate uptake of feed products with reduce enteric methane emissions in dairy cattle	High	Medium	High	Few definitive figures on nutrition as a whole, more evidence on particular forages
Supporting and incentivising improved sheep nutrition – intensive	Medium	Cost saving	Low	
Supporting and incentivising improved sheep nutrition – extensive	Low	Cost saving	Low	Few definitive figures on nutrition as a whole, more evidence on particular forages
Support and incentivise genetic improvement of sheep	Medium	Low	Low	Less evidence than breeding for cattle
Support maintaining and improving sheep health	Medium	Medium	High	Emerging evidence from Teagasc (Ireland), practicalities of implementation challenging
Supporting appropriate uptake of feed products with reduce enteric methane emissions in sheep	Medium	Medium	Low	
Efficient nutrient management	Medium	Cost saving	High	Same as measures 2 and 3?