Efficient Farming cuts Greenhouse Gases

Greenhouse Gas Reduction Strategy and Action Plan – promoting and encouraging the adoption of technical efficiency to improve farm business performance and reduce greenhouse gas emissions.

Report by the Agriculture and Forestry Greenhouse Gas Stakeholder Group

2011

The Agriculture and Forestry Greenhouse Gas Stakeholder Group member organisations:

Department of
Agriculture and
Rural Development
www.dardni.gov.uk
AN ROINN
Talmhaíochta agus
Forbartha Tuaithe
MÄNNYSTRIE O
Fairms an
Kintra Fordèrin

NIAPA
Northern Ireland
Agriculture Producers Association

COUNCIL FOR NATURE CONSERVATION
AND THE COUNTRYSIDE
An Advisory Council to the Department of the
Environment

LMC
Livestock & Meat Commission

nimea
Northern Ireland Meat Exporters Association

Ulster Farmers' Union

Northern Ireland
Grain Trade Association

Confor
Promoting forestry and wood

IAP
Industry Advisory Panel

Dairy UK
NORTHERN IRELAND

Ministerial Foreword

Climate change presents a challenge to agriculture worldwide – the need to produce more food and non-food products whilst reducing the impact on the local and global environment.

We must jointly accept our responsibility to future generations and reduce the net greenhouse gas (GHG) emissions from agricultural production alongside other sectors of the economy while managing the increasing demand for food, water and energy in the face of a changing climate.

Lowering carbon also needs to complement, and not compete with, sustainable growth objectives and the drive to improve competitiveness in the agri-food sector.

Influencing the sector is a complex undertaking: it comprises many small businesses, widely spread geographically, each responsible for different types of GHG emissions (nitrous oxide and methane). Furthermore, the ability of different soils and plants to sequester carbon varies by farm; the impacts of climate change – and the adaptations required, vary too.

There is no 'silver bullet' to reduce emissions but I firmly believe that the right combination of mitigation measures, communicated clearly, implemented voluntarily by industry and measured accurately, is the way forward and will show the buyers of our products that we have a more sustainable future. A flexible and adaptable approach is needed to make progress in changing farm practices and responding to emerging/new scientific knowledge.

Following discussions with the Industry Advisory Panel (IAP), DARD established an internal Steering Group during 2009 and in 2010 established a Greenhouse Gas Stakeholder Group to develop a range of primary production focused mitigation measures based on available scientific evidence.

This strategy and action plan is an important first step, by the industry in reducing carbon intensity in the agriculture sector. I want to see continued close co-operation with the agriculture, forestry and environmental representatives on the GHG Stakeholder Group to show our competitors and customers, in an expanding market, that we can effectively address this critical issue.

DARD will remain fully engaged as the group implements the strategy and will continue to provide the scientific evidence to develop further mitigation measures. DARD will also contribute to the cross departmental work on GHG emissions reductions and the Sustainable Development Implementation Plan in order to achieve the Executive's priorities. Successfully implementing this framework of mitigation measures is a central part of our overall local approach and DARD, AFBI and CAFRE will have key roles respectively in keeping abreast of policy developments, scientific developments and communicating advisory messages.

I congratulate the Group on their work to date on this complex challenge and look forward to the implementation of these measures and their contribution to the targets for reduction set locally and at Member State level.

Michelle O'Neill MLA

Minister of Agriculture and

Rural Development

Executive Summary

The agriculture and forestry sectors are committed to playing their part in carbon reduction and contributing to meeting targets for reductions in emissions.

During 2010/11 the GHG Stakeholder Group has been working to determine how best to encourage farmers and landowners to take actions that will reduce the emission intensity of food production.

This strategy and action plan identifies a suite of measures and actions that can be progressively implemented on-farm to better manage and thereby reduce the inevitable consequences of agri-food production systems i.e. methane and nitrous oxide.

Higher levels of productivity and reduced animal wastage as a result of lower disease incidence enables a given demand for livestock products to be met with lower emissions.

Promotion of awareness of agriculture GHGs is the initial focus alongside increased production efficiency to deliver GHG savings and develop more robust and sustainable farm businesses.

There are numerous existing mechanisms to improve efficiency and we now need to take steps to assess their impact on GHGs and ensure more widespread adoption of measures that can contribute to further reductions over time.

We will ensure that scientific research underpins all we recommend and will seek to ensure that we exploit existing and trusted delivery routes where possible. The existing partnership between industry and DARD is vital and will minimise duplication of effort. A simple governance structure has been established to develop further our planned joint approach and delivery of actions.

Agriculture GHGs have reduced since 1990, mainly due to reduced chemical fertiliser use and manure management. Livestock numbers have also reduced since 1998. Therefore, for example, lower use of chemical fertiliser and further reduction in livestock numbers is not a sustainable way forward. By meeting the GHG reduction challenge by decreasing our carbon intensity per unit of commodity output, growing production in a sustainable way to meet increasing demands for food we can contribute to food security and a prosperous agri-food sector.

This strategy and action plan complement many other sustainability, environmental and biodiversity initiatives, targets and EC Directives.

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Current Position

Although Climate Change is a devolved issue, how we tackle it is influenced by EU and UK policies and legislation.

- **EU and UK targets under Climate Change Act 2008.**

The EU has enacted legislation to reduce emissions by 20% by 2020 (taking 1990 as the base), while the UK has set the legally binding target of reducing emissions by 34% by 2020 and at least 80% by 2050.

There has been some speculation on whether other sectors should set more ambitious emissions reduction targets so that food production is not constrained.

The Climate Change Act 2008 is UK legislation that extends to Northern Ireland with the consent of the Northern Ireland Executive and Assembly. It sets a long-term framework for the UK to reduce its GHG emissions including:

- A legal framework to reduce emissions by at least 80% below 1990 levels by 2050 and by at least 34% in the period 2018-2022;
- Compliance with a system of five-year carbon budgets;
- The setting up of a Committee on Climate Change (CCC) to advise government;
- Publication of a Climate Change Risk Assessment on Adaptation.

According to the UK emissions inventory, agriculture accounts for around 8% of all UK emissions – around 48 MtCO_2e. Currently land use, land use change and forestry reduces UK emissions by 2 MtCO_2e per year, although this sector is projected to become a net emitter by 2013 due to a decline in the historic tree planting rate. Agriculture therefore contributes significantly to emission levels, but it is also part of the solution. It is the only main emitting sector in the local economy (others being energy production and transport) which can also offset greenhouse gas emissions through locking up carbon in grass, soil and plants. The sector also provides multiple social, economic and environmental benefits and therefore its relationship with the Climate Change agenda is complex, interconnected and unique.

The nature of agriculture GHG emissions is very different from other sectors of the economy such as electricity generation, transport and manufacturing. The principal greenhouse gas for most industries is carbon dioxide (CO_2) from fossil fuel combustion, while for agricultural systems methane and nitrous oxide are the main GHGs. Determining these emissions is much more complex than measuring CO_2, and they are bound up in highly complex and imperfectly understood natural soil and animal microbial processes. These processes are not directly controllable by human intervention, and furthermore they are subject to seasonal and annual variability and are dependent upon weather, crop yield, etc.

A supply of nitrogen from organic or inorganic sources is an absolute requirement for the growth of crops and pasture, and it is an unavoidable consequence of soil processes that some of the nitrogen in an agricultural system will be emitted as nitrous oxide. Likewise, methane is produced by bacteria in the rumen of cattle and sheep as they break down the cellulose in their diet, producing milk and meat for human consumption from the large areas of grassland that are often unsuitable for arable crops.

The Challenges for Agriculture in the North

These are similar to many other regions and include:

- Farming involves complex natural cycles and therefore there are technical difficulties and physical limitations on emission reduction.
- Food demand is predicted to double globally by 2050. The island of Ireland is well placed to produce safe, quality food whilst safeguarding the environment.
- Food products are mainly exported. If local food production is reduced to reduce emissions, production will increase elsewhere with greater emissions.
- The degree of uncertainty regarding agriculture emissions and the effect of changing practices on these emissions relative to other sectors.
- Nitrous Oxide is 310 times more powerful as a greenhouse gas than CO_2 and agriculture is the single largest contributor of this gas (75% of total UK N_20 emissions).
- Methane is 21 times more powerful as a greenhouse gas than CO_2 (38% of total UK CH_4 emissions).
- The identification of the most cost effective mitigation strategies for agriculture, whilst safeguarding food production capacity.
- Agriculture and other land management practices have a positive role to play in climate change mitigation as carbon can be sequestered in living biomass (vegetation) or as soil organic matter.
- N_2O emissions from agriculture have declined by 18% from 1990 to 2009 and by 25% since peak emissions in 1998. Combinations of reduced chemical fertiliser usage and a reduction in ruminant livestock numbers following CAP reforms are the likely causes. CH_4 emissions have declined by 6.9% in 2009 relative to peak methane emissions in 1998 due to a reduction in ruminant livestock numbers following CAP reform in 1998. However, methane emissions in 2009 were similar to those reported in 1990.

Reductions in CH_4 and N_2O emissions from better livestock management and improved nutrient and fertilizer management are likely to have the most potential and can achieve multiple environmental objectives, for example, improved manure management and better nitrogen efficiency, which have a direct impact on emissions.

There is a risk that the Northern Ireland agri-food sector may become uncompetitive in its main markets if it does not further reduce GHG emissions at least in line with other regions' ambitions e.g. Scottish Farming for a Better Climate Strategy, 10% reduction by 2020 based on 2006 levels.

The focus in this reduction strategy is on measures that are known to enhance both economic performance and reduce GHG emissions per unit of output. This sets a strategic direction for the sector that, from an economic perspective, minimises future risks arising from current uncertainty while also improving economic competitiveness by reducing cost.

It is clear that for local products to continue to compete for growing markets both nationally and internationally, steps must be taken to ensure that carbon intensity of local food production is reduced, at least in line with other regions. It is therefore essential that a strategy for delivering sustainable emissions reductions is implemented very soon to ensure a steady reduction trajectory up to 2020 and beyond.

Scientific Rationale

Greenhouse gas (GHG) emissions from agriculture are primarily due to the release of methane, as a result of enteric fermentation in ruminants, and the production of nitrous oxide from soils, artificial fertilisers and organic manures. Enteric fermentation (methane) accounts for approximately 39% of GHG emissions from agriculture in Northern Ireland, methane loss from animal manures accounting for a further 7% of emissions, with agricultural soils (nitrous oxide) accounting for 39% of emissions, as shown in Table 1[1]. Land use, land use change and forestry (LULUCF) is a small net source of CO_2 with the grassland net sink of -1.3 Mt CO_2e partially offsetting emissions from cropland and settlements.

Table1: Source of Greenhouse Gas Emissions from the Agri-Food sector in Northern Ireland in 2009 (MtCO_2e)

	1990	2009	% Change
Agriculture			
Total emissions	5.81	5.20	-10.5
Enteric fermentation	2.04	2.05	0.0
Manure management	0.67	0.64	-4.5
Agricultural soils	2.49	2.03	-18.5
Agricultural engines and agrochemicals	0.61	0.48	-21.3
Land Use, Land Use Change and Forestry (LULUCF)			
Total emissions	0.1	0.1	
Forest	-0.74	-0.48	
Cropland	+1.32	1.08	
Grassland	-1.16	-1.26	
Settlements	0.57	0.81	
Other (inc wet lands)	0.08	-0.04	

[1]-AEA (2011)

Agricultural production within Northern Ireland is relatively efficient, when considered on a global scale in terms of nutrient efficiency i.e. livestock or crop output per unit of nutrient input. However, as highlighted elsewhere in this document, there is increased pressure on all sectors of the economy, including agriculture, to reduce GHG emissions in order to meet national GHG reduction targets. Coupled with this is the need to increase global food production to meet the needs of an increasing population, and this presents particular opportunities for the local agri-food sector. In this context, reductions in the emission intensity of food production will be critical, with greater reductions in intensity required as food production increases.

Uncertainties in inventories associated with the agri-food sector

The agriculture inventory accounts for nitrous oxide and methane from this sector, with estimates of emissions based almost entirely on Tier 1 of the Intergovernmental Panel on Climate Change (IPCC). The Tier 1 approach uses standard emission factors for livestock and fertiliser and applies these to national statistics on livestock numbers and fertiliser N use. An IPCC Tier 2 approach is used for emissions resulting from manure management and methane emissions from dairy cows and cattle, based on emission factors derived for specific countries.

However, a much more accurate Tier III approach is required for estimation of actual emissions from agriculture in Northern Ireland – this involves detailed modelling to improve the spatial and temporal resolution of the inventory. In addition to providing more accurate assessment of actual emissions, a more accurate inventory will also provide more appropriate recognition for specific mitigation strategies.

Improvement of the agriculture inventory is being addressed through a major Defra/DARD/Scottish Government funded study. The inventory model will specifically cover:-

- Methane emissions from enteric fermentation – from ruminants and some non-ruminants;
- Methane emission from manure management – during the storage, treatment and land application of manure and from direct excretal returns of grazing animals;
- Nitrous oxide emissions from managed soils – direct emissions from synthetic fertilisers and excretal returns from grazing animals;

- Nitrous oxide emissions from organic manures following land application.

The LULUCF inventory is primarily concerned with CO_2 removals and emissions, with some small emissions of methane and nitrous oxide also included. Removal of CO_2 from the atmosphere (C sequestration) is mainly through forest growth and increases in wood products, and also through changes in land use which result in increased C levels in soil and vegetation. Global estimates indicate that permanent pastures have the potential to offset up to 4% of global GHG emissions. However, detailed information is lacking on the critical factors controlling the transfer, fate and longevity of C inputs to soil under different farming systems. For this reason, DARD has recently agreed funding for research in the Agri Food and Biosciences Institute to address this gap in knowledge.

This work, coupled with further refinement of the LULUCF inventory, should result in development of higher resolution activity data, development of more representative emission factors, disaggregation of land use class e.g. differentiation between upland blanket-bog and improved grassland; and better information on the C sequestration potential of managed grassland.

Whilst carbon dioxide emissions are not accounted for within the agriculture inventory, as fossil fuel use in agriculture is accounted for under the energy sector, use of bio energy crops as substitutes for fossil fuel use offers significant GHG mitigation potential.

Mitigation Potential

One of the main challenges in reducing emissions from agriculture is that most animal and crop production systems involve complex natural cycles, with interactions between various parts of the system and physical limits on emission reduction. Nonetheless, there are significant opportunities for GHG mitigation in agriculture and in many cases these are associated with improved biological efficiency and have potential to lower production costs.

The Department is funding a research programme to explore and develop novel abatement strategies. These include mitigation practices involving dietary modification, genetic selection and adoption of improved manure management strategies.

Details on inventory improvements, the DARD commissioned research programme to the Agri Food and Biosciences Institute and the Research Challenge Fund are included at Annex 4.

Details on Scientific Research underpinning each implementation measure are also included at Annex 4.

Economic Rationale

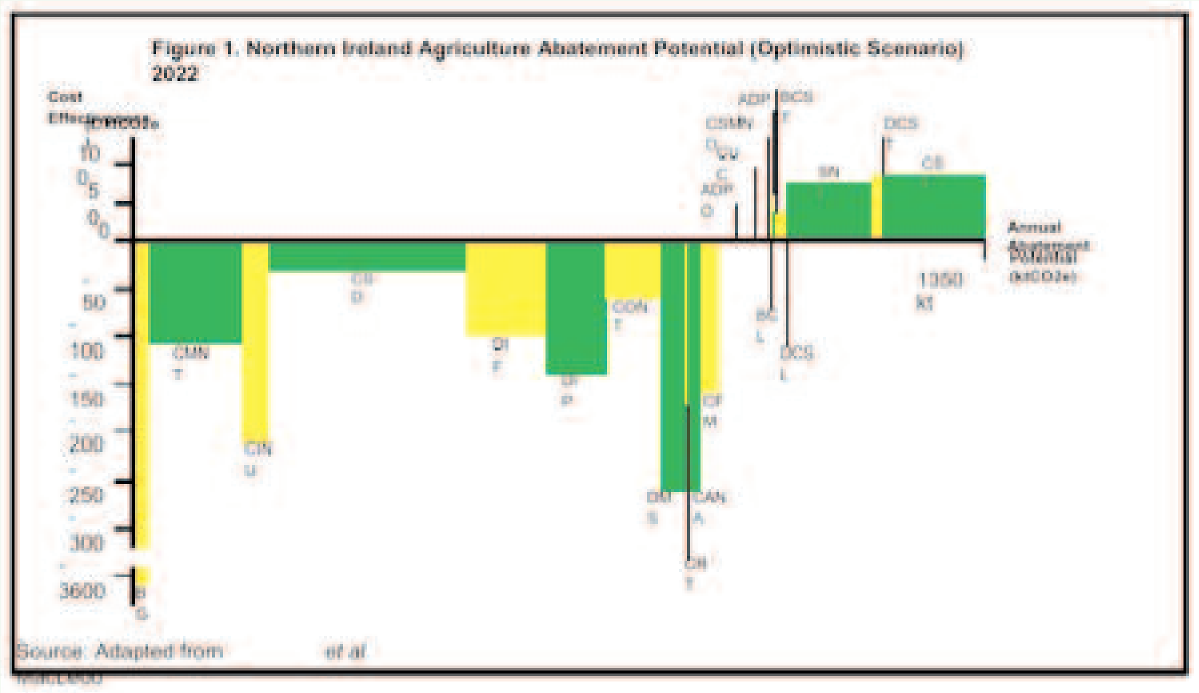
Cost-effective GHG emission reduction

Faced with the need to reduce GHG emissions, it makes sense to do so in a cost-effective way. To inform debate on the issue the Committee on Climate Change commissioned research relevant to agriculture. This involved estimating the emissions savings arising from the adoption of a range of technologies (and changes in management practice) at farm-level. The results[2], produced using a technique known as marginal abatement cost curves analysis (MACCs), contrasted the potential to reduce emissions with the net costs of implementation. Estimates were computed for the UK as a whole and each of the Devolved Administrations.

Ranking mitigation measures from the study in order of decreasing cost-effectiveness permits technologies and changes in farm practices to be compared at the margin (i.e. the steps of the curve). In the diagram below for agriculture in Northern Ireland, measures on the left, below the horizontal-axis indicate net savings to farm businesses, while costs to the right, above the axis show activities with a net cost. The wider the column, the greater is the abatement potential of the measure. The taller the column, the greater is the net saving (below the horizontal axis) or the net cost (above the horizontal axis).

The main message is that a number of technologies or farm practices appear to deliver both reductions in GHG emissions per unit of output and improvements in farm profit.

[2]MacLeod, M., Moran, D. et al, (2010). 'Review and update of UK marginal abatement cost curves for agriculture'. SAC, ADAS, University of Edinburgh.



Key:

BG – Beef Improved Genetics
CSD – Crops Soil Drainage
CONT – Crops Organic N Timing
CANA – Crops Avoid N Excess
CUC – Crops Using Compost
ADPI – Anaerobic Digestion Pigs
SNI – Soils Nitrification Inhibitors
CMNT – Crops Mineral N Timing
DIF – Dairy Improved Fertility
DMS – Dairy Maize Silage
CFM – Crops Full Manure
CSMND – Crops Slurry Mineral N Delayed
BCST – Beef Covers Slurry Tanks
DCST – Dairy Covers Slurry Tanks
CINU – Crops Improved N Use Plants
DIP – Dairy Improved Productivity
CRT – Crops Reduced Tillage
ADPO – Anaerobic Digestion Poultry
BCL – Beef Covers Lagoons
DCSL – Dairy Covers Slurry Lagoons
CSI – Crops Species Introductions

The quantities in Figure 1 are emission savings for a given year, relative to the baseline. Reductions in methane and nitrous oxide are expressed as carbon dioxide equivalents (CO_2e). The emissions savings should be viewed as the potential difference between CO_2e emitted in a business as usual scenario and emissions in the abatement scenario where a particular technology or mitigation measure is employed for a reasonable period of time.

The MACC analysis examines technical opportunities, the extent of their mitigation potential (avoidable emissions) and the likely unit cost. Its main strength is that, by using a standard framework, it presents a 'big picture' analysis. It therefore allows a broad, rather than in-depth, analysis of opportunities within a common structure.

Measures with a net cost in Figure 1 (those above the horizontal axis) may well be worthwhile depending on the circumstances that apply and the broader policy context. For example, if GHG emissions were taxed, then mitigation measures costing less than the value of the tax to implement could be economically viable.

The analysis is intended to improve our understanding of the opportunities, costs and benefits of GHG abatement. It is not intended to be policy-prescriptive and does not set out the policies or programmes necessary to deliver these opportunities. Some of the assumptions in the underlying analysis may not be appropriate to NI conditions, for example the use of maize silage on dairy farms.

Key Principles

The focus of this strategy is based on the following principles:

- Production efficiency gains should be the focus of activity – we are seeking to improve the resource efficiency of production and reduce emissions per unit of commodity output, whilst providing flexibility to meet future market demands.

- The agricultural GHG inventory should accurately reflect progressive changes in local farming practices, such as improvements to livestock diets, nutrient management and manure management.

- Recognition should be given to all other GHG costs and benefits associated with the industry, such as the contribution of on-farm renewable energy and the storage of carbon in grass, soils and plants.

- To capture existing good practice, and provide a potentially more cost-effective way of addressing the climate change challenge than regulation.

- To proceed on the basis of voluntary actions based on good practice.

Strategy Outline

The Strategic Objective is to promote and encourage the adoption of a programme of technical efficiency measures on-farm that will lead to improved business performance and help reduce GHG emissions. Our ambition is to reduce emissions per unit of commodity output and have a robust measurement methodology on which to base targets for reduction by 2013.

Our strategy at the highest level aims to:

- Improve the agriculture and land use GHG inventories by smartening the measurement to include local circumstances;
- Research scientifically the potential for locking in more carbon in soil/grass initially and in peatland later, also to reduce GHG emission levels at production system level – dairy and beef initially, and continue to look at opportunities for renewable energy – biomass in particular;
- Encourage implementation by communicating firstly, to farmers and land owners and secondly, to customers, a number of measures that we know can achieve emissions reductions and keep working on a number of measures that we would want to implement in the future. (Farmer based case studies have been developed to promote practices and more will be added in the future); and
- While doing this we will develop and integrate GHG reduction advice into existing services and investigate how the NIRDP 2014-2020 might be structured to comply with the EC's outline greening proposals. A main objective of the CAP will be sustainable management of natural resources and climate action – to pursue climate change mitigation and adaptation actions thus enabling agriculture to respond to climate change.

Taking the Strategy Forward

Phase I	**Theme – Awareness Raising**
(Dec 2011 – Mar 2013)	- Establish a robust delivery partnership
	- Improve awareness
	- Begin implementation
	- Use scientific research results
Phase II	**Theme – On-farm Implementation**
(2013 – 2014)	- Wider scale implementation
	- To be informed by results from awareness phase, Defra policy review in 2012 and CAP proposed changes
	- An updated action plan will be published in Spring 2013
Phase III	**Theme – Precision on-farm Implementation**
(2014 – 2020)	- To be informed by new inventory measurements and CAP implementation
	- An updated action plan will be published in Spring 2014

Phase 1 - Awareness

Objectives

These objectives will focus on the implementation themes and mitigation measures identified.

Objectives include:

- Establishing a robust partnership that will stimulate and deliver the voluntary adoption of on farm practices that improve production efficiency.

- Improving awareness amongst farmers and growers of GHG emissions and of particular farm practices that will improve efficiency and business performance, whilst simultaneously reducing emissions.

- Beginning the implementation of on-farm practices that reduce GHG emissions per unit of commodity output in a manner that promotes animal health and welfare and environmental protection by:

  (i) using science to continuously update technical advice and decision making tools.

  (ii) developing innovative and effective means of delivering business and technical advice to farmers and growers that motivates and enables them to adopt improved practice.

- Use scientific research results on the improvement of the GHG agriculture inventory to ensure fit-for-purpose information is supplied and also assessing outputs from local scientific projects that inform direction on mitigation measures.

Implementation Themes

This framework primarily addresses the role of producers and land owners within the total supply chain.

Four key themes designed to reduce emissions intensity have been identified:

- **A - Better nutrient and fertilizer management** (mainly minimal costs but incentives available);
- **B - Better livestock management** (with mainly moderate costs);
- **C** - Optimising **renewable energy** generation and encouraging **fuel efficiency** on farms (high installation costs but incentives available);
- **D** - Better land management by **locking in carbon** in soils, peatlands and grass (unclear magnitude of potential and costs, research results pending); and
  Better land management by **locking in carbon** in new and existing woodlands (mainly moderate costs but incentives available).

Annex 5 provides more detail on individual implementation measures.

Mitigation measures that result in emission reductions while delivering the many other vital public goods expected of this sector, such as: food production, biodiversity, water quality and renewable energy, are optimum.

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Case Study 1

Dairy – Nutrient Management

Reduction Framework Ref: A1, A2, A3, A4

Pat Lavery farms on the edge of Lough Neagh in County Armagh. The farm land runs down to the banks of the River Bann. The layout of the farm requires Pat to farm in an environmentally sensitive manner, with continual monitoring that the high standards set for the farm are maintained.

Currently the farm runs a dairy herd of 90 Holstein / Friesian cows plus followers. High physical and financial performance is achieved, with a rolling yield of 8,100 litres of milk sold per cow per year and over 4,000 litres taken from forage. This level of production coupled to controlled overhead costs places the farm business in the top quartile of CAFRE benchmarked farms.

To achieve these results the focus for Pat is growing and utilizing quality grass for either grazing or silage by the herd. Stocking rate is maintained to ensure the organic nitrogen loading on the farm remains less than 170 kg N/Ha.

To consistently meet these targets for herd performance and environmental standards, Pat recognises the importance and value of nutrient management planning. Soil analysis is a matter of routine on this farm with all fields analysed on a 5-6 year cycle. To help plan fertilizer applications throughout the year, Pat uses the on-line nutrient management calculators developed by DARD. Zero-P fertilizer has been used since 2003 with phosphate only purchased and applied where soil analysis and crop demand show a requirement.

The Lavery farm has been part of an AFBI research project since 2005 monitoring the impact of management practices on soil fertility and crop yields. As a result of this work lime is spread annually to ensure optimum pH for fertilizer efficiency and inorganic fertiliser with added sulphur is used to grow grass for second cut silage.

Case Study 1

The farm always had sufficient slurry storage capacity but to ensure all slurry could be stored and used at the correct time an additional tank was constructed under the Farm Nutrient Management Scheme. Over the past three years the farm has fully utilized slurry nutrients by a combination of soil analysis, correct timing of application as a result of storage flexibility and using the services of a contractor to spread the slurry by either trailing shoe or shallow injection.

Pat says – "some farmers may consider nutrient management planning as a waste of time, however to me it is essential as it makes good economic sense. The results I have achieved testify to the benefits. In addition the latest information from research shows that efficient farming and utilizing all farm resources effectively has a positive environmental impact, reducing green house gas production. Efficient farming to make money is my aim and I want my system to be sustainable for whoever farms after me – in essence it is commonsense".

Benefits seen:

- Annual planning of fertilizer requirements.
- Since 2005 a 50% reduction in chemical fertilizer usage.
- Improved herd profitability.
- Reduced N fertilizer usage leading to less nitrous oxide production.
- Improving efficiency has reduced greenhouse gas emission per litre of milk.

Challenges faced:

- Maintaining sward productivity under difficult weather conditions.
- Ensuring compliance with regulations.
- Milk price volatility.

Case Study 2

Arable (Potatoes) – Nutrient Management

Reduction Framework Ref: A3, A4, C4

Ian McMaster, Broughshane

Ian has been developing the family potato business with his wife Laura outside Broughshane since the year 2000 and has recently been joined by his son Robert. Ian's potato enterprise involves the growing of 35-40ha of processing potatoes annually. These are processed through the diversification business 'Chip Master' which supplies local chip shops and restaurants with fresh pre-prepared potato and vegetable products.

Attention to detail with Potato production and storage

Ian's approach to growing the crop focuses on careful field selection to maximise yield potential. This involves selecting free draining fields which allow flexibility in field operations and where possible larger fields which allow for more efficient field operations. Ian also aims to rent grassland from dairy farms which generally has higher nutrient content and this approach combined with detailed nutrient management planning ensures efficient fertiliser usage taking account of any available organic manures. This attention to detail has consistently enabled Ian to grow high yields of suitable quality potatoes to be processed through the 'Chip Master' business. The crop is stored on the farm in a combination of ambient and refrigerated storage. The stores are computer controlled to ensure efficiency and the refrigerated section was sized to fit with the requirements of the business helping to reduce empty space in the store which would make the refrigerated store require more energy. When possible any extra space in the store is sub-let to ensure the store is as full as possible. This practice combined with empty boxes being returned to the store as it is emptied, further reduce energy use.

Case Study 2

Reduction of food miles

The ‘Chip Master’ business supplies over 1500tonnes of processed potatoes and vegetable products directly to shops and restaurants each year. The result is that Ian’s potato crop is grown processed and consumed within a 50 mile radius, having a major beneficial effect on the food miles incurred and hence carbon footprint as much of his product has substituted previously imported frozen chips and potatoes.

Improvement of processing facilities

Ian continues to strive for improved efficiency and has recently upgraded the processing facilities with the help of DARD’s Processing and Marketing grant scheme which has streamlined handling of the crop.

Benefits seen

- Reduced growing costs.
- Improved yields.
- Returns improved by adding value to the crop.
- Improved efficiency in the field and in the factory.
- More efficient practices have helped to reduce carbon output.

Challenges faced

- Diversifying into a new business.
- Ensuring there is attention to detail at all stages to maintain quality.

Case Study 3

Arable (Barley & Wheat) and Woodland – Nutrient Management & Locking in Carbon

Reduction Framework Ref: A3, A4, C4, D3, D4

Allan Chambers, Downpatrick

Allan farms 284 hectares near Downpatrick in partnership with his brother David. The farm has always been renowned for efficient farming, typified by the fact that the first grey Ferguson tractor in the north of Ireland was purchased by their father following a demonstration in 1936. The openness to adopt new technology to improve efficiency remains in the business today, but not at the expense of good traditional husbandry methods, which help maximise yields.

The cereal yield figures for the farm are impressive, with 2011 harvest yields currently 9.98t/ha for Winter Barley 9.96t/ha for Spring Barley, and Winter Wheat so far yielding 12.1t/ha.

These yield figures are achieved through 3 key areas, all of which help reduce the emissions per ton of cereal produced.

1. Efficient use of nutrients

Allan applies all crop nutrient requirements on the basis of soil analysis and according to the DEFRA RB209 fertiliser manual to maintain yields and avoid waste. Allan has also achieved further efficiency and carbon reductions through the use of organic manures, especially broiler litter of which the farm uses 1000tonnes per annum, replacing approximately 100tons of chemical fertiliser. This has brought two benefits firstly a cheaper nutrient source but secondly improved soil condition and earthworm activity have helped ease cultivations.

2. Good crop rotations

Allan has always focused on the overall farm efficiency and recognises the benefits of break crops both in improving soil structure and in spreading workload. Spring break crops are the key focus as these fit best with the efficient use of organic manures by ensuring the maximum availability of the nitrogen. The current break crops are potatoes, linseed, forage maize and 2 year Italian ryegrass for haylage production.

Case Study 3

3. Effective land use

Thirteen years ago Allan recognised that there were areas of the farm which were less productive and difficult to farm which were limiting field operations and reducing average yields. With the assistance of the woodland grant scheme, 16 Ha of native woodland were established to produce wood from these less productive cropping areas. This resulted in a more efficient arable crops enterprise, improved biodiversity, and also created a carbon sink on the farm.

Efficient machinery and equipment policy

Following their fathers approach to the grey Ferguson tractor, Allan and David recognise the benefits of new efficient machinery developments in improving work rates and timeliness of operations. However, they are also focused on maximising the working life of equipment through good maintenance, helping to reduce costs and their carbon footprint further. Where sufficient work does not exist on the farm to fully justify owning a machine, long standing relationships have been developed with local contractors to supply these services, reducing costs and improving efficiency.

Benefits seen

- Costs have decreased.
- Chemical fertiliser usage has decreased.
- Improved soil condition.
- Easier cultivation.
- Spread of workload.
- Better field efficiency.
- Improving efficiency has reduced carbon emissions.
- Increased yield.
- Improved biodiversity.

Challenges faced

- Increased management required.
- More co-ordination of field operations required.
- Ensuring timing of operations fits with rotations.
- Making sure nutrition levels are optimised for each crop.
- Ensuring compliance with regulations.

Case Study 4

Sheep – Livestock Management - Improving Upland flock performance

Reduction Framework Ref: B1, B4

Maurice McHenry, Ballintoy.

Maurice and his family farm a 120 ha hill farm on the North Antrim Coast. This is an extensive hill farm comprising of large areas of heather moorland and rough grazing, with only 6 ha of improved grassland. They run a crossbred ewe flock of 260 ewes and 50 replacement hoggets.

His emphasis has been to develop a closed crossbred flock that will achieve a good lamb output by, selection of breeding stock based on recorded information through his Electronic Identification recording system.

Maurice has been involved in assessing a wide range of breed crosses on his farm as well as a number of research projects including resistance in fluke/worm drenches, lameness in sheep and the use of selenium/iodine boluses. Through these projects he has recognised the benefits of crossbreeding and changed his system from a blackface flock to a crossbred flock.

Maurice states that:

“I am more interested in how a sheep performs than how she looks. This is why the EID recording package has been so useful to us, as we can now select replacements which exploit genetics selected for hybrid vigour and performance.”

Case Study 4

Benefits seen:

- Lamb rearing % has increased by 20% over the last five years.
- Kgs carcase produced/ha has increased by 25% over this period.
- Kgs carcase sold per ewe has increased from 21kg to 28kg over the 5 year period.
- Gross Margin /Ewe has improved by 22%.
- The flock is now a self replacing flock.
- The improvement in performance has helped to lower the carbon emissions per kg carcase.

Challenge faced:

- Getting Rams with recorded figures.
- Making more and better use of the information within the EID recording package.
- Getting more out of grass through better utilisation and management.

Case Study 5

Sheep – Livestock Management using records to build an efficient ewe flock
Reduction Framework Ref: B1, B3
John Martin, Greyabbey

John farms the 78 ha Gordonall Farm in Greyabbey. Sheep are the main enterprise with 450 breeding sheep, including 100 homebred ewe lambs.

The emphasis is to develop a composite flock of breeding sheep with reduced labour requirement and high output, by focusing on genetics, animal health and feed efficiency.

Crossbreeding is a top priority. All sires purchased are performance recorded with selection for maternal traits.
To make best use of grazed grass, a significant proportion of the flock are turned out to grass 4 weeks before lambing and lambed out-side.
John is involved in the easy-care management research through AFBI, Hillsborough.

"I used to select my ewe lamb replacements on appearance. But for the past 4 years I've been using the Hillsborough Management Recording Scheme to identify my best performing ewes - those for fertility, high growth rates and no lambing problems. The recording takes time but if I can increase my lamb output while reducing labour, in the long term it is worth it. "

Case Study 5

Benefits seen:

- Feed costs and labour costs have decreased.
- Overall flock health has improved.
- Lambs sold per ewe has increased by 11%.
- Kgs carcase produced / ha has improved by 30%.
- Gross Margin per ewe has increased by 44%.
- Improving the technical performance of the sheep has lowered costs of production and carbon emissions per kg of carcase produced.

Challenges faced:

- Sourcing quality performance recorded rams.
- Getting into the mindset of recording all lambing and other flock data on a Personal Digital Assistant (PDA).

Case Study 6

Dairy – Livestock Management (2)

Reduction Framework Ref: B2, B3

Drew McConnell

Drew and Val McConnell and family, farm in the very scenic area of Carrigans, Co Tyrone just on the edge of the Sperrins. The home farm is now in the third generation of McConnells and extends to 77 Ha. An additional 48 Ha is rented annually and all the land farmed in Less Favoured Area of predominantly heavy clay soil type. Rainfall is over 1250 mm each year thus the farm requires attention to detail and flexibility in management practices to avoid poaching and structural damage to allow the farm to remain productive and profitable.

Since taking over the farm in 1993 Drew and Val have undertaken significant farm development with investment in land improvements, milk quota and new buildings. The main enterprise on the farm is a 150 cow autumn/winter calving Holstein / Friesian herd rearing 80 dairy heifers for own use and sale. As some of the farm rises to over 230 metres, suckler cows and a flock of breeding ewes utilize this severely disadvantaged land.

Drew says “the key objectives for the farm are four fold –

- to maximise profit per hectare
- to have a labour efficient working environment
- to improve cow comfort and welfare
- farm in an environmentally positive manner
- to continue farming in a manner which gives satisfaction and enjoyment within the constraints of farm resources.

To try and meet these objectives is a team effort by all involved, everyone has an important role to play.”

The results achieved demonstrate how effectively the farm is managed. The dairy herd has an average 305 day yield of 9,529 litres of high compositional quality at 4.24% B.F. and 3.38% Protein. A target has been set to increase life time yield to 40,000 litres by improving cow longevity. This will reduce greenhouse gas emissions by X% through reductions in replacement rate.

Drew continues “to do so means cows which are bred for improved health and fertility, with good legs and feet and the capacity to effectively utilize grass and grass silage. Through our management input we must seek to provide an environment where the cow can achieve her genetic potential and maintain a high herd health status.

Case Study 6

This is why we place so much emphasise on cow comfort and welfare. The milk market is demanding and we must try to meet these market requirements through a sustainable production system."

The McConnell family are actively involved in a number of research and knowledge and technology transfer projects with AFBI, CAFRE and private sector partners. A comment was made by the family "all the research evidence shows the importance of having healthy productive livestock to minimize the number of lost or empty days. This is what good farming is all about and if we can help get this simple message across through our involvement in these projects. We have applied the research findings across a range of areas on the farm. Particular emphasise have been placed on heifer rearing, dry cow management and milk compositional quality and all have contributed to the successful and better management of the farm and in doing so addresses the real need to produce milk with a low carbon footprint. In fact through a DARD Research Challenge Fund led by Agri-Search we are piloting a new Greenhouse Gas Calculator currently being developed by AFBI. If our farm can be used to demonstrate the benefits to other farmers of implementing research and using new tools such as the carbon calculator, then we are only too pleased."

Benefits seen:

- Milk production from forage is 3400 l, 50% than the average farm.
- Costs of production per litre 20% lower than the average farm.
- Improved herd fertility and lower replacement rates reducing GHG emissions by X%.
- Profitable and sustainable dairy farming system.

Challenges faced:

- Dairy farming in the Less Favoured Area.
- Increasing costs of production.
- Further legislation.

Case Study 7

Beef – Livestock Management improving productivity from the suckler herd

Reduction Framework Ref: B2

Billy O'Kane, Ballymena.

Billy O'Kane runs a 400 acre all grass farm at Crebilly near Ballymena. The main enterprises are beef and sheep production and the farm currently carries 90 spring calving beef cows and 1,000 outdoor lambing ewes.

His emphasis is to maximize returns through efficient production and enjoy farming by adopting lower input beef system. Key to this is utilising genetics selected for fertility, docility and easy calving. This has enabled heifers to be calved down at 24 months of age rather than 36 months and beef to be produced from a predominately grass based system.

In 2005 the decision was made to introduce the Stabiliser composite breed. The Stabiliser was developed through a large scale research programme in Nebraska. Stabiliser bulls have been used on the herd over the past six seasons and the herd will be 85% Stabiliser bred by 2012.

Billy states that 'calving at 24 months of age rather than 36 months brings financial benefits to my business of £44 for every cow in my herd and reduces the environmental impact of every kilo of beef I produce'.

Case Study 7

Benefits seen:

- A tight calving period.
- Fewer resources are invested in the heifer.
- By calving heifers at 24 months, there are 12% less stock on the farm.
- Calving index less than 365 days.
- Weaning 96 calves per 100 cows put to the bull.
- Producing 350kg carcases in 14 months from bulls fed less than 1 tonne concentrates.

Challenge faced:

- Producing heifers weighing 420kg ready for bulling at 15 months.
- Making more use of grass/clover swards.

Case Study 8

Beef & Sheep – Livestock Management increased reliance on clover reduces GHG emissions

Reduction Framework Ref: A3, D1

John Milligan, Castlewellan

John farms 79 ha of LFA land, 36 ha on his home farm between Spa and Castlewellan, with the remaining block near Dromara. His main enterprise is beef and sheep. The 55 suckler cows, producing stores and finished beef, are served with a Limousin bull and some A.I. Additional dairy bred Angus and Hereford cross calves are bought in to improve output per cow. The 220 ewes, served with Texel, Charollais, Lleyn and Rouge rams, have a lambing percentage of around 170%. The overall stocking rate is 1.9 CE/ha.

John's aim is to maximise stock liveweight gain from grass and clover. This involves planned reseeding and sward improvement using a range of methods to ensure high quality grass and clover and attention is paid to grazing management.

Grass and clover varieties sown are selected from AFBI's recommended list. Fertilizer nitrogen application is minimised by increasing reliance on clover and making more efficient use of slurry. Grazing is rotational on the main farm block to maximise efficiency in grass utilization. This allows grass and clover to be rested and given a chance to build up high quality herbage for the next grazing in the rotation.

John says 'While I have raised stocking rate and made significant cuts in some inputs I intend to continue to improve profitability by further increase in stocking rate without significant increase in inputs. With this higher efficiency I expect to make further reduction in GHG emissions.'

Case Study 8

Benefits seen:

To farm business

- Liveweight gains have increased.
- Target weights are reached earlier.
- Less concentrates are needed during the winter.
- More grass is available to flush ewes in autumn.
- Profitability has increased.

To GHG emissions

- Reduced by more than 10% due to:

  - minimum cultivation (less carbon dioxide)

  - reduced N fertiliser usage (less nitrous oxide)

  - improved animal production efficiency (less methane).

Challenges faced:

- Maintaining adequate clover in swards.
- Continuing:

  - to increase stocking rate and output at current input

  - to reduce emissions.

Case Study 9

Horticulture – Mushrooms - Energy Efficiency Cuts Carbon

Reduction Framework Ref: C2, C4

McKeever Bros

The Co Tyrone mushroom unit of Anthony and Declan McKeever produces over 200 tonnes of mushrooms annually from seven tunnels.

Following an energy audit on their unit carried out by CAFRE they have introduced a number of energy efficiency measures.

A new 70 kW condensing boiler was installed in January 2011 to supply hot water for a number of the tunnels, replacing an old inefficient oil boiler. The new boiler works at above 90% efficiency compared to the 65% level of the original boiler.

Oil Savings

This change is reflected in the oil consumption figures for the unit. In 2010 total usage was 23,760 litres. To mid September 2011 the usage has been 14,000 litres. Considering the seasonality of production this indicates a total usage in 2011 of around 18,500 litres, a 22% reduction on the previous year. This has been achieved in spite of an increase in the tonnage of mushrooms produced in the unit. **The use of 5,260 litres less oil means a reduction in emissions of 14 tonnes of CO2 annually on an ongoing basis.**

Insulation

Insulation of the water distribution pipe-work was inadequate and this is currently being upgraded with proprietary district heating pipe-work costing £42 per metre.

Studies indicate that using this type of insulation can reduce heat loss by up to 70% compared to the previous thinner nitrile rubber covering

Reducing heating and cooling costs

The tunnels have been covered externally with Nicotarp. This costs £2,000 more than the conventional plastic covering. However, it has better insulating properties and therefore reduces both the heating and cooling costs for the unit.

Case Study 9

The energy efficiency measures made to date have contributed both to an improved financial margin and a reduced carbon footprint for the unit.

Lighting

The lighting in the tunnels is being progressively upgraded from switch start fluorescent tubes to electronic start fluorescents. These are 20% more efficient. These changes are reflected in the changes in the annual electricity usage. Total electricity usage in 2010 was 48,025 kWh and based on bills to date will be around 40,000 kWh in 2011. This reduction of 16.7% represents an annual CO_2 emission reduction of 4.4 t.

Benefits seen:

- Costs have decreased.
- 22% reduction in oil use.
- 16.7% reduction in electricity use.
- 18 t CO_2 emissions saved annually.
- Better energy efficiency.
- Heat losses reduced.
- Carbon footprint reduced.

Challenges faced

- High cost of pipework.

Case Study 10

Arable – Wheat - Renewable Energy Cuts Carbon

Reduction Framework Ref: C2, C3, C4

Kane Bros, Limavady

Michael and Boyd Kane grow 180 ha of cereals and 15 ha of SRC willow in Limavady. In 2008, they installed a 110kW woodchip boiler to provide the heat for their grain drying floors. Around 1500 tonnes of winter and spring crop is dried with this system. The drying floors are also used to dry around 200 tonnes of willow-chip each year which is used to fuel the boiler and provide a high quality fuel for sale. Heat is also provided to the dwelling house and self catering apartments when the dryer is not in use.

What are the financial savings?

We had been using around 30,000 litres of oil for drying, and a further 10,000 litres for heating the house and letting apartments. This oil has been replaced by roughly 160 tonnes SRC willow at 20%MC at a value of £80 per tonne. At a current oil price of £0.58 per litre, the biomass heating system saves us almost £10,500 per year. We still have a bit to go as the recently installed second chip boiler is not yet running to its full capability and we have to supplement peak heating demands with oil. Government figures assume 90% efficiency for oil, whereas we get about 95% using a space heater which blows straight into the drying tunnels.

What other benefits have you seen?

It is encouraging when we hear continually of the rising cost of oil, that we are able to utilise a product grown on the farm to supply a considerable portion of our energy needs, and that the savings increase each time the price of oil goes up. As burning home produced is carbon neutral, it helps to know that we are reducing the carbon footprint of the farm and the grain we produce quite considerably.

What challenges have you faced?

One of the major challenges we faced was the loss of farming income during the establishment of the SRC willow, building up the knowledge base, and the time that this took whilst carrying on intensive cereal farming and diversifying into tourism. Finding local installers with a sufficient understanding of the infrastructure requirements of the system was quite difficult and at times frustrating.

Case Study 10

What about the future?

We have already installed a 5kW Iskra wind turbine to help reduce our electricity bill and to give some extra income from the portion we sell to the Grid.

A second biomass boiler has now been installed which indicates how satisfied we are with the contribution renewable energy can make to the efficiency of our farming operations.

We have also decided to replace a 35 year old fan with a more energy efficient motor, and have began to fine-tune the system through the use of data-logging and monitoring and control software. This enables us to use heating and electricity for the drying fans more efficiently, and hopefully achieve better savings and more efficient energy use in the future.

Benefits seen

- Costs have decreased.
- Savings of £10,500 per year.
- Reduction in oil use.
- 150 t CO2 emissions saved annually.
- Better energy efficiency.
- Future energy price rises controlled.
- Carbon footprint reduced.

Challenges faced

- Initial cashflow interrupted.
- Knowledge level of technology.

Future Plans

- Wind turbine installed.
- Second biomass boiler.
- More energy efficient motors.
- More monitoring and control.

Case Study 11

Pigs - Energy Efficiency Cuts Carbon

Reduction Framework Ref: C4

Co Down Farmer

Following an energy audit carried out by CAFRE, a Co Down pig producer has made a number of energy saving changes on his unit.

Home mixing

As part of the home mixing process, ground material on this unit was blown by fan from the hammer mill to the mixer. The energy audit identified this process as highly inefficient in terms of energy usage. In mid 2010 the producer took the opportunity to replace the hammer mill with one without a fan. The ground feed is now augered from the hammer mill to the mixer. At the same time the original one tonne mixer was replaced with a four tonne mixer. Installation of the larger mixer allows four times the amount of feed to be mixed in the same amount of time. In the 12 months since the installation of the new hammer mill and mixer the producer has seen a reduction in his electricity bill despite over twice as much pig feed now being mixed.

Lighting

On pig units lighting is required by both stock and stock people.

It is estimated that lighting accounts for 10-15 percent of electricity supplied to a unit. On this unit although efficient lighting had been installed in the newer pig housing tungsten bulbs were still in use in an older finishing house. The tungsten bulbs, which are only 5 percent efficient at converting energy to light, were replaced with compact fluorescent lights. Compact fluorescent lights are four to five times more efficient than tungsten bulbs. Replacing the 100 watt tungsten bulbs with 20 watt compact fluorescent lights reduced the annual energy usage by 1600 kWh. This 1600 kWh saving represents an annual reduction in CO_2 emissions of 880kg.

Monitoring heat pads

Investigations carried out by the Farm Energy Centre show that at least 25 percent of energy consumption occurs in the farrowing house. This equates to a usage of approximately 160 kWh per sow per year. On this unit supplementary heat is provided by water heat pads and

Case Study 11

the owner is currently monitoring their energy consumption. His aim is to calculate the running costs of the heat pads and to benchmark this cost with the cost of other supplementary heating systems. He also regularly checks the actual temperature of the heat pads as experience has shown that temperature control of heat pads often lacks precision. Poor temperature control leads to overheating of pads resulting in wasted energy. A 20 percent reduction in energy usage as a result of improved control equates to a saving of 1000 litres of oil per year on this unit. This saving in oil represents an annual reduction in CO_2 emissions of 2.65t.

The energy efficiency measures made to date on this unit have resulted in both reduced electricity costs and a lower carbon footprint.

Benefits seen:

- Milling & mixing costs halved per tonne output.
- Less electricity used for lighting.
- Improved temperature control on heat pads.
- 1000 litres of oil saved annually.
- Over 3.5 t CO_2 emissions saved annually.
- Carbon footprint reduced.

Case Study 12

Sustainable Forestry

Reduction Framework Ref: D4

Baronscourt Estate has 1,442ha of woodland located in the west of Tyrone which is being transformed to and managed under a continuous cover permanent forest system.

The transformation process began in 2001 after a trip to Lower Saxony in Germany where we saw what could be achieved with such a system.

The productive forest areas are thinned every four years, when the trees are selected for harvest on an individual basis, removing the poor quality stems early on to allow the better quality specimens to grow on to their maximum value.

All the trees are removed as a thinning, the intensity of which is calculated to remove only the volume produced by the forest since the last harvesting operation.

This ensures the forest remains intact and that our harvest is sustainable.

Case Study 12

Benefits Seen

- No clearfelling which ensures a permanent forest cover.
- Which provides a rich, diverse and secure habitat.
- Maintenance and enhancement of the local landscape.
- Maintenance of the forest microclimate.
- Flood mitigation.
- Permanent carbon sink.
- Reduction in the use of chemicals.
- Production of carbon neutral products and fuel.

Challenges Faced:

- Initial unpredictability of yield and therefore income.
- Initiating natural regeneration of tree species.
- Rhododendron ponticum control.
- Reduction of the Sika deer herd.
- Introduction of mixed tree species.
- Selling mixed quality, mixed species parcels.
- Unknown system in the locality, advice and training has to be sought abroad.

Annex 1 – Climate Change Drivers

- **Executive PFG target and work of Cross Departmental Working Group.**

  The 2007 Programme for Government (PfG) contains a target to reduce greenhouse gas emissions by 25% below 1990 levels by 2025. This target was set before the Climate Change Act of 2008 and while there is no specific target or carbon budget for Northern Ireland in the Climate Change Act 2008, it is implicit that Northern Ireland contributes to the UK effort.

  A Cross Departmental Working Group (CDWG) on Climate Change has identified that to maximise emission reductions in a cost effective way, all Northern Ireland departments must not only ensure their actions and functions drive emissions reductions but that they work together to realise this goal and influence their particular sector of the NI economy.

  The CDWG has acknowledged that that measurement of emissions needs to be improved and refined especially in the agriculture sector and has noted the work on the agriculture inventory and that policies must be fully appraised for costs and benefits and quantified in terms of greenhouse gas emissions where possible.

  The CDWG also notes that while the agricultural sector in Northern Ireland is showing a downward trend due mainly to a fall in animal numbers and lower chemical fertilizer use, that the sector will need to go further to ensure business competiveness particularly given the market pressures to demonstrate the sustainability of food production.

  Regional tools used for the CDWG's GHG's projections (based on limited data) which take into account all sectors of the economy, while informative, are not the key focus for buyers of NI agricultural produce. Comparisons and calculations of embedded carbon in products e.g. a litre of milk or a kg of beef, are increasingly used by buyers as a key sustainability criteria. Sustainability in the agriculture sector spans social and economic sustainability in addition to environmental considerations.

- **Position in NI compared to GB and ROI.**

  In 2009 (the latest available figures), overall NI emissions were estimated to be 19.5 MtCO_2e). This represents a reduction of 20% in emissions since 1990, which compares favourably with reductions of 21.1% and 21.3% for England and Scotland respectively.

Annex 1

There is a greater degree of uncertainly in greenhouse gas estimates at individual country level than at the UK level. Agriculture, power generation, housing and transport dominate the local emissions landscape.

The Northern Ireland emissions estimates have a confidence interval of +/- 33% and are particularly weak in agriculture and land use. (The GHG agriculture and land use inventory refinement programmes will address this)

The latest GHG Inventory estimates indicate that agriculture accounted for 26.7% of Northern Ireland emissions in 2009, with CH_4 and N_2O being the main source of emissions. Land Use Change acts as a small carbon source.

England

England set 3 $MtCO_2e$ as a minimum target reduction in emissions to achieve by 2020 in their Agriculture Low Carbon Transition Plan published in July 2009.

A GHG Action Plan (GHGAP), sometimes referred to as a voluntary action plan, was issued in 2009. Delivery of Phase I was published in April 2011. The focus is on encouraging farmers to adopt a number of priority actions that will help reduce greenhouse gas emissions, rather than attempting to quantify the precise level of reduction involved with each action.

DEFRA plan to review implementation of the GHGAP in 2012. This will include an assessment of performance on the commitments contained in the dairy, beef and sheep, and pig roadmaps and any other relevant sector activity.

Scotland

The Climate Change Act 2008 extends to Scotland in the same way as for Northern Ireland. However, Scotland has passed its own legislation known as the Climate Change (Scotland) Act 2009. This legislation includes targets to reduce emissions by 42% in 2020 relative to 1990 and 80% in 2050 relative to 1990. The Scottish Act also provides for the setting of annual emission targets.

Scotland published its Agriculture Climate Change Delivery Plan in June 2009 proposing a reduction target of 1.3 $MtCO_2e$ by 2020, the equivalent of 10%.

The Scottish Farming for A Better Climate (FFBC) initiative was launched in 2010 to provide better information and advice to land owners. The Scottish Government are currently seeking tenders for monitoring uptake of the FFBC.

Annex 1

Wales

Wales has set a reduction target of between 0.6 $MtCO_2e$ (10% below 2008 level) and 1.5 $MtCO_2e$ by 2020 in its Climate Change Strategy announced in October 2010. In addition to the provisions of the Climate Change Act 2008, the Welsh Assembly Government has made a commitment from 2011 for Wales to reduce annual GHG emissions by 3% in areas of devolved competence. A Welsh Agriculture Stakeholders Group has reported to WAG and the Minister has announced further woodland planting and that an internal team will work on how to implement 44 of the 49 recommendations which have been accepted. Better husbandry, better use of chemical fertilizers and manures and AD are included.

ROI

In December 2009, the Republic of Ireland published a framework document on a Climate Change Bill, which is modelled on the UK Act. It proposed to set 3% annual reduction targets with an 80% reduction on 1990 levels by 2050. More recently, legislative proposals in ROI failed to gain support. Vociferous opposition was evident from farming unions'. Currently ROI emissions from agriculture are estimated to be at 27% which is the highest in the EU.

- **Market signals from retailers including their interest in Life Cycle Carbon Calculators.**

Supermarket inspired on-farm carbon footprinting continues in a limited way in NI mainly flowing from GB based initiatives.

Bord Bia in ROI recently announced at a leading international food conference, in response to market signals, an extensive data gathering exercise to assess footprints linked to quality assurance schemes. There have also been claims that lower input spring calving systems which dominate the ROI dairy sector have lower carbon than huge input autumn calving systems which dominate the NI dairy sector.

Welsh sheep farmers have also recently claimed lower carbon from their systems as a Unique Selling Point (USP). New Zealand lamb is also marketed as low carbon due to the increasing levels of sequestration due to large increases in forestation and efficiency gains.

Wider sustainability of supply considerations are believed to be gaining prominence with international buyers.

Annex 1

- **Indications from EU of importance of climate change as a policy driver.**

  The structure and budgets for the CAP 2014-2020 have not yet been published but all indications are that climate change will be added to the existing list of priority areas for action.

  More generally the EU's Europe 2020 Strategy influences the Executive's European policy priorities: Competitiveness and Employment; Innovation and Technology; Climate Change and Energy; and Social Cohesion.

  Within the Climate Change priority key aims include: promotion of resource efficiency, increasing use of renewable energy, exploiting new technology to reduce emissions and taking advantage of opportunities under the CAP.

  The Europe 2020 Flagship Initiative: 'Resource Efficient Europe' aims to help decouple economic growth from the use of resources by decarbonising our economy.

- **Reports of Climate Change Committee up to and including the 4th Carbon Budget period.**

  The CCC acknowledged that "the scale of the opportunities to reduce emissions from agriculture is more uncertain than in other sectors". These assumed that UK-wide annual reductions of 5 $MtCO_2e$ can be achieved from the agricultural sector over the 4th carbon budget period, in addition to the 4.5 $MtCO_2e$ (3 $MtCO_2e$ for England) annual reductions to be delivered by 2020.

  The CCC also acknowledge that the vast bulk of these emissions are methane and nitrous oxide emissions arising from biological processes, affected by variables such as climate, weather and soil conditions. These baseline figures currently used in the UK inventory are calculated by multiplying a measure of activity by an "emission factor" which does not generally take account of these variations.

  Following an investment by DEFRA in November 2010 of £12million – co-funded with the Devolved Administrations – work is now underway to improve the evidence base so as to increase the accuracy of the inventory and gain a better understanding of the level of emissions reduction that can be achieved.

  The CCC also says that CAP and other factors with an impact on production levels are likely to be strong drivers of emissions from the agriculture sector and that it would not make sense to reduce agriculture-related greenhouse gas emissions in the UK simply to export the environmental consequences of food production elsewhere.

Against this background, the CCC acknowledges that the strategy has been to focus on the positive practical action that can be taken to deliver reductions in greenhouse gas emissions and improve our understanding of the challenge ahead, while remaining cautious about aiming for particular targets that would imply a level of accuracy we do not have at present.

This strategy includes challenging the industry to lead the promotion and delivery of practical on-farm measures that will reduce emissions through improved resource efficiency.

The analysis suggests that the majority of the abatement potential is cost-effective at a carbon price of £0 per tonne and therefore represents a potential cost saving for farmers and that further policy strengthening – including taxation or direct regulation – to encourage the implementation of on farm actions should be considered.

It shows that there are significant opportunities to reduce emissions at negative or zero cost before 2020, with further opportunities by 2030, some of which are likely to be at higher cost but less than the projected carbon price. However as the Climate Change Committee notes, there is considerable uncertainty on how to reduce GHGs beyond 2030.

The 2009 UK Low Carbon Transition Plan (LCTP) included an ambition to reduce emissions by 3Mt $C0_2e$ in the period 2018-2020. This scales up to 4.5Mt $C0_2e$ for the UK as a whole.

New analysis from the CCC in 2010 states that their 2008 predictions were on the conservative side and they believe there is far greater abatement potential in the sector than the targets that have been set.

The CCC's last report also said that **all** regions of the UK should have plans in place to reduce emissions. They acknowledged the work being carried out in Northern Ireland.

- **Sustainable Development (SD)**

Sustainability remains a key retail buyer consideration. Additionally, developing and helping implement this framework is a key action point for DARD within the SD Implementation Plan published by the Executive in May 2010. DARD is lead department for the promotion of sustainable land management.

Annex 2 – Communication Plan including priorities for Dairy, Beef/Sheep, Arable

GHG Sub-Group – Communications Strategy

- **Background**

  The GHG Sub-Group was set up by the Agriculture and Forestry Greenhouse Gas Stakeholder Group to develop a strategy which effectively communicates the key messages to all stakeholders from the joint industry/DARD GHG strategy. The group comprised individuals representing the Red Meat Strategic Forum (RMSF), Dairy (NI) UK Board, Ulster Arable Society (UAS) and DARD.

  The group initially decided to focus efforts on ruminant livestock and arable crops as they were the main sectors where gains could be achieved in the short term. Each of these sectors (through group representation) then identified and prioritised the key mitigation measures which could be adopted on-farm within each sector.

- **Key Message and Audience**

  The group recommends that the over-arching theme for the communication strategy should be **"Efficient farming cuts Greenhouse Gases"**. The strategy is to promote and encourage the adoption of technical efficiency on farm leading to improved business performance and reduced GHG emissions. It was also felt that this approach could also be used by the agri-food industry to demonstrate a proactive and forward thinking industry willing to face up to and meet its challenges.

  The group recommends that the communication strategy should not only detail the mitigation measures to be adopted on-farm now and into the future but should also promote the GHG emission gains from the past. These could include the reductions in nitrogen and phosphorus applications, improved use of organic manures (Farm Nutrient Management Scheme) and the increased outputs in particular milk yields.

  The target audience to be communicated with is viewed as all parts of the agri-food supply chain including the consumer. The key stakeholders can be broadly divided into internal (public sector) – DARD, Invest NI, DOE and MLAs and external – farmers, food processors, retailers, consumers and the media. The message must be tailored to meet audience need and this is more clearly set out later.

The group recommends that the communication strategy should be initially delivered from late 2011 (following the issue of the reduction strategy) and be formally reviewed March 2013. The key communication focus will be farmers/processors however it was also felt by the group there was a need to communicate through events/publications/media to wider stakeholders.

- **Communication methods and success**

As the main focus of the strategy is farmers/processors the main communication methods were identified below and many of these channels will also assist communication with agri-food supply chain and agricultural media:

- Knowledge and Technology Transfer events through CAFRE including education programmes to those entering the industry. The CAFRE farm is also a channel through which new technology can be developed and demonstrated on mitigation measures to the wider industry.
- Press articles, bulletins, booklets eg. LMC, United Newsletter
- Internet sites – DARD, RMSF, UFU, AFBI, UAS, Dairy (UK), NBA, NSA and food processing company sites.
- Focus Farms/Monitor Farms/Research Farms – integrate communication within the existing messages.

The methods used to communicate with wider supply chain stakeholders, MLAs, other Govt Depts, consumers will be through press/media articles.

The group recommends that the following measures of success should be set out and monitored over the period of the strategy:

i. Initial baseline study to gauge awareness of knowledge and attitude to GHG emissions. This study could be completed as part of Communication students' studies at Loughry Campus, CAFRE and should be repeated March 2013.

ii. 3000 farmers attending events where they are informed about mitigation measures to reduce GHG emissions.

iii. Evaluations carried out at the end of each of the events/demos/training over the period of the communication strategy.

Annex 2

- **Mitigation Measures**

The following tables set out the agreed prioritised mitigation measures to be communicated on a sector basis:

a. **Dairying**

Mitigation Measure	Communication Method	Lead Responsibility
B3 – Improving feed efficiency	KTT and industry training events, Focus Farms	CAFRE / AFBI
A4 – Nutrient Management Planning	KTT and industry training events, Focus Farms	CAFRE
A1/A2 – Timing and Application of slurry	KTT and industry training events,	CAFRE / AFBI
B2 – Genetic improvement	KTT events, Research farms	CAFRE / AFBI
C4 – On-farm energy efficiency	KTT and industry training events	CAFRE
A3 – Grass / clover production	KTT and industry training events, Monitor farms	CAFRE

b. **Beef / Sheep**

Mitigation Measure	Communication Method	Lead Responsibility
B1 / B2 – Genetic improvement	Research Farms, KTT events	AFBI / CAFRE/ RMSF
B3 – Improving feed efficiency	KTT and industry training events, Focus Farms	CAFRE/AFBI/ RMSF
B4 – Targeting waste as a result of disease - BVD	Industry training event, Focus Farms, Research Farms	AFBI/CAFRE/ UFU
A3 – Grass / clover swards	KTT and industry training events, Focus Farms	CAFRE/RMSF
A1 / A2 -Timing and application of slurry	KTT and industry training events, Focus Farms	CAFRE/RMSF

c. Arable

Mitigation Measure	Communication Method	Lead Responsibility
A4 – Nutrient Management Planning	KTT and industry training events, Focus Farms	CAFRE
C4 – Energy Efficiency	KTT and industry training events	CAFRE
B1 – Plant genetic Improvement	Research Farms, KTT events	AFBI / CAFRE/ UAS
A1/A2 – Timing and application of slurry	KTT and industry training events, Focus Farms	CAFRE/UAS
D3/D4 – Creation of new and management of existing woodlands	Awareness events	Forestry Service

- **Key messages – other stakeholders**

As previously highlighted it is essential to communicate to wider government and the supply chain (including consumers) that the agri-food industry is working to reduce its environmental footprint. The group recommends holding an event to launch the GHG Strategy to the key stakeholders. This event should highlight the positive messages emanating from the agri-food industry on GHG emission reduction (past and future) and be launched by the Minister.

Annex 3 - Action Plan

Annex 3 – Phase 1 Action Plan/Measurement/Targets

Phase 1 – Theme – Increase Awareness of GHGs and Mitigation Measures to reduce emissions – Timescale – Dec 11 to March 13				
Activity				
Action Area	**Current**	**New**	**Delivery Channel**	**Indicators of Progress**
Establish a robust delivery partnership to: - Drive and monitor progress - Motivate partners to help early promulgation of key messages - Report on performance	Agri and Forestry GHG Stakeholder Group.	**Action 1** Agri and Forestry GHG Implementation Partnership AF GHG IP (An entity which will be responsive to changes in policy, scientific developments and farming circumstances). - up to 3 meetings per year to monitor progress. - decide on sub-groups to lead on particular objectives. - Establish dialogue with retailer organisations and other key players in the food supply chain about the role they play in advice and providing incentives. - membership to strike a balance between involving partner organisations while remaining manageable and flexible to respond to new circumstances.	Existing group to decide way forward.	Implementation Partnership to be agreed and established before launch of Reduction Framework.

Annex 3 - Action Plan

Annex 3 – Phase 1 Action Plan/Measurement/Targets

Phase 1 – Theme – Increase Awareness of GHGs and Mitigation Measures to reduce emissions – Timescale – Dec 11 to March 13				
Activity				
Action Area	**Current**	**New**	**Delivery Channel**	**Indicators of Progress**
Awareness of Reduction Framework.	There is minimal awareness of agriculture GHGs and that efficiency increases have a direct correlation to reducing GHGs.	**Action 2** Develop a baseline figure for current awareness of knowledge of GHGs within primary production. **Action 3** Launch Reduction Framework on member websites. **Action 4** Launch event attended by GHG Stakeholder Group members, agri media and Minister. **Action 5** Promotion of Reduction Framework at: - AgriSearch Events - CAFRE Industry Training and KTT Events - AFBI Research Open Days	DARD lead. DARD to make web based Reduction Framework available to member organisations at launch. DARD lead. All Stakeholders.	Benchmark data on awareness available at launch.

Annex 3 - Action Plan

Annex 3 – Phase 1 Action Plan/Measurement/Targets

Phase 1 – Theme – Increase Awareness of GHGs and Mitigation Measures to reduce emissions – Timescale – Dec 11 to March 13				
Activity				
Action Area	**Current**	**New**	**Delivery Channel**	**Indicators of Progress**
Begin Implementation.		**Action 6** Current activity items listed under the Drive Implementation sections below will be assessed where appropriate in terms of their GHG reduction impacts and will also be used to establish potential reduction per unit of commodity output.	DARD with CCC advice.	A CCC approved indicator Framework by March 2013.

Annex 3 - Action Plan

Annex 3 – Phase 1 Action Plan/Measurement/Targets

Phase 1 – Theme – Increase Awareness of GHGs and Mitigation Measures to reduce emissions – Timescale – Dec 11 to March 13				
Activity				
Action Area	**Current**	**New**	**Delivery Channel**	**Indicators of Progress**
Nutrient Management.	Nutrient Management - Nitrates Action Programme (NAP) applies to all farms. Designated fertiliser spreading times. Minimum of 22 weeks slurry storage capacity (FNMS supported 3900+ new/replacement tanks). Nutrient Management Plans on derogated farms. - METS (Manure Efficiency Technology Scheme) - AES (Agri Environment Schemes) - Farm Nut. And Farm Waste Mgt Plans - On line nutrient management calculators	**Action 7** Nutrient Management Plans (NMPs) – 700 farmers to attend by March 2013.	DARD (CAFRE) Lead Farming Unions to target and encourage farmers to attend and complete NMPs.	Number attending courses. Number completing NMPs.

Annex 3 - Action Plan

Annex 3 – Phase 1 Action Plan/Measurement/Targets

Phase 1 – Theme – Increase Awareness of GHGs and Mitigation Measures to reduce emissions – Timescale – Dec 11 to March 13				
Activity				
Action Area	**Current**	**New**	**Delivery Channel**	**Indicators of Progress**
Begin Implementation Livestock Management.		**Action 8** To encourage farmers to calve heifers at 24 months of age.	DARD (CAFRE) lead through industry training programmes and the implementation of R&D through knowledge and technology transfer.	Number attending training. Number adopting technologies. Age assessment at calving through Aphis towards target of 24 months age at first calving. GHG benefits to be identified by AFBI.
	Dairy and Suckler Cow Fertility Challenges.	**Action 9** Revised £PLI (Profitable Livestock Index) for dairy and revised EBV's (Estimated Breeding Value) for beef. Implementation onto farms through training and KTT.	As above.	Numbers attending training and complete herd fertility plan. Numbers adopting technologies Calving interval Aphis Fertility Benchmarking Financial Benchmarking. GHG benefits to be identified by AFBI.

Annex 3 - Action Plan

Annex 3 – Phase 1 Action Plan/Measurement/Targets

Phase 1 – Theme – Increase Awareness of GHGs and Mitigation Measures to reduce emissions – Timescale – Dec 11 to March 13				
Activity				
Action Area	**Current**	**New**	**Delivery Channel**	**Indicators of Progress**
	Animal health and Welfare Training programmes Currently provide awareness on control and the benefits.	**Action 10** Target BVD Control in cattle and liver fluke in sheep.	Partnership to deliver with Farming Unions, PVPs DARD Veterinary Service and CAFRE Industry Training and KTT events.	National screening survey. Number of farmers attending training and implementing a herd or flock health plan.
	Production Efficiency.	**Action 11** Campaign on understanding £PLI and using it on-farm to make long term breeding decisions. Feed efficiency to harness genetics Trait recording to underpin genetic improvement programmes.	Launched at the Dairy Genetic Conference October 2011 and will be followed by on-farm workshops. Specific training programmes. Industry partnerships with AI and breeding companies. Agri-Search to deliver breed for specific market outlets and reduced empty days.	Genetic evaluation by AFBI. Number of farmers attending training, developing breeding plans and implementing the plans. Carcase gain. Total milk solid gains.

Annex 3 - Action Plan

Annex 3 – Phase 1 Action Plan/Measurement/Targets

Phase 1 – Theme – Increase Awareness of GHGs and Mitigation Measures to reduce emissions – Timescale – Dec 11 to March 13				
Activity				
Action Area	**Current**	**New**	**Delivery Channel**	**Indicators of Progress**
Begin Implementation. Renewable Energy.	Renewable Energy - implementation of the DARD Renewable Energy Action Plan 2010. - Training and Awareness. - Research Programme. - Sustainability Criteria. - Financial support for RE on-farm installation - Supply Chain Development Programme. Energy Efficiency - training. - knowledge & technology transfer. - adoption. - benchmarking.	**Action 12** Implement Review Recommendations from the Renewable Energy External Stakeholder Group. **Action 13** Tranche 2 (T2) of financial support for RE on-farm installation. **Action 14** Lessons learnt from Tranche 1 applicants. **Action 15** 1000 to attend training 1000 to attend K&TT events 110 businesses adopting 400 businesses completing benchmarking.	DARD/AFBI/Farming unions/food processors. DARD (CCREB) to advertise opening of Tranche 2 funding. Farming Unions to target those known to be considering investments. DARD (CAFRE) lead with GHG Stakeholders to promote attendance on their websites	Capability expansion within the Agricultural and Forestry Sector. 20+ applications to T2.

Annex 3 - Action Plan

Annex 3 – Phase 1 Action Plan/Measurement/Targets

Phase 1 – Theme – Increase Awareness of GHGs and Mitigation Measures to reduce emissions – Timescale – Dec 11 to March 13				
Activity				
Action Area	**Current**	**New**	**Delivery Channel**	**Indicators of Progress**
Begin Implementation Locking in Carbon.	Locking in Carbon - Woodland Grant Scheme and Farm Woodland Premium Scheme. - AES Tree Planting.	**Action 16** Manage the WGS/FWPS to deliver the area of woodland creation identified in Forest Service Business Plan (2000ha in 2011/12). **Action 17** Manage 61000 ha of existing Forest Service woodland in a sustainable manner, including the regeneration of woodland after felling.	DARD (Forest Service). DARD (CMB). Forest Service Woodland Stakeholder Group.	Progress in achieving targets – AES and Forest coverage.

Annex 3 - Action Plan

Annex 3 – Phase 1 Action Plan/Measurement/Targets

Phase 1 – Theme – Increase Awareness of GHGs and Mitigation Measures to reduce emissions – Timescale – Dec 11 to March 13				
Activity				
Action Area	**Current**	**New**	**Delivery Channel**	**Indicators of Progress**
Use scientific research results.	- GHG inventory development projects(5). - DARD commissioned research Projects (6)(GHG and RE). Footprint (Dairy and Beef). Breeding Strategies (Sheep). Potential of amending urea (with a urease inhibitor) as a fertiliser to replace CAN Carbon Sequestration rates for grassland and peatland soils. Digestate Management. Biomass crops and technologies. Farmscale AD. - Research Challenge Fund Projects (2).	**Action 18** Quarterly reporting of progress and presentation of results including interim results to AF GHG IP. **Action 19** Identification of evidence gaps.	AFBI reporting findings. AF GHG IP to consider results and promote by dissemination to members. DARD/Industry.	- Rate of adjustments to mitigation practices. - Rate of dissemination of scientific findings. - Rate of knowledge transfer. - Rate of adjustments to mitigation practices. - Rate of dissemination of scientific findings. - Rate of knowledge transfer.

Annex 4 – Scientific research underpinning each implementation measure and scientific case studies (3)

Details of Scientific Studies Supporting Proposed Options

AI: Slurry application via trailing shoe versus splash plate

Manure N efficiency increased by up to 39%. Average improvement in grass yield of 26%. Chemical "sparing" effect of up to 44 kg N/ha at slurry application rate of 55 t/ha.

Reference: Frost, J.P., Gilkinson, S.R. and Binnie, R.C. (2007). Methods of spreading slurry to improve N efficiency on grassland. In High Value Grassland: Providing Biodiversity, A Clean Environment and Premium Products. Proceedings British Grassland Society Occasional Symposium, pp 82-87.

GHG reduction. Assuming 50 t slurry applied by trailing shoe rather than splash plate reduces chemical N application rate by 44 kg N/ha, this will reduce GHG emissions as follows:-

IPPC (2006) emission factor for inorganic N fertiliser is 0.01 kg N_20 per kg N applied.

For 44 kg N/ha this equates to a reduction of 0.44 kg N_20/ha or (298 x 0.44) kg $C0_2e$ = 131 kg $C0_2e$/ha due to reduced inorganic N application.

Edwards-Jones et al (2009) also indicate a reduction in GHG emissions of 6.28kg $C0_2$/kg N due to fertilizer N manufacture. This equates to 44 x 6.28 = 276 kg $C0_2e$/ha.

Total reduction in GHG emissions = 276 + 131 = 407 kg $C0_2e$/ha.

Reference: IPPC (2006). Guidelines for National Greenhouse Gas Inventories Volume 4: Agriculture, Forestry and Other Land Use.

Edwards-Jones, G., Plassmann, K and Harris, IM (2009)
Carbon footprinting of lamb and beef production systems:
Insights from an empirical analysis of farms in Wales. J Agric Sci (Camb) 147: 707-719.

A2 Timing of slurry application by splash plate

(a) Time of application. Aim should be to apply slurry in spring as this enables nutrients to be applied during a period when nutrient uptake by herbage is high and ammonia and leaching losses are relatively low.

N-fertiliser replacement value of slurry in spring is 0.35 compared to 0.20 for summer (Defra, 2006). Furthermore Pain et al (1986) observed a 14% lower efficiency for 80 kg N/ha applied as slurry in March April (0.38) compared to an application in May-June (0.24).

References: Defra (2006). Fertiliser recommendations for agricultural and horticultural crops (RB209), Norwich UK: The Stationery Office.

Pain, B., Smith, K.A. and Dyer, C.J. (1986). Factors affecting the response of cut grass to the nitrogen content of dairy cow slurry. Agricultural Wastes, 17: 189-202.

(b) Timing of application relative to inorganic nitrogen fertiliser application. Timing of slurry application relative to application of chemical fertiliser N can have a major effect on N_20 emissions. The readily decomposable C present in organic manures can enhance denitrification of nitrate in soil, and the situation is exacerbated when fertilisers containing nitrate are applied at the same time (Stevens and Laughlin, 2002). These authors concluded that overall times of application cattle slurry applied at the same time as nitrate fertiliser caused an additional 2.9% of the nitrate fertiliser to be emitted as nitrous oxide. The extra emission could largely be avoided by delaying application of chemical N fertiliser until at least 3 days after slurry application.

Reference: Stevens, R.J. and Laughlin, R.J. (2002). Cattle slurry applied before fertilizer nitrate lowers nitrous oxide and dinitrogen emissions. Soil Sci Soc Am J. 66 647-652.

(c) Type of chemical N fertiliser. Type of chemical N fertiliser can have a marked effect on N_20 emissions. For example, lower N20 losses tend to occur with ammonium nitrate fertilisers rather than urea when nitrification is the main loss process, whereas nitrate forms of fertiliser should not be used under wet conditions when denitrification is the main source of N_20 emissions. Research in AFBI has shown that, under wet conditions in May, N_20 emissions were up to three times greater from a calcium ammonium nitrate-based fertiliser compared to urea-based fertilisers (Dampney et al, 2004: Watson et al, 2009).

Reference: Dampney, P.M.R., Chadwick, D., Smith, K.A. and Bhogal, A. (2004). The behaviour of some different N fertiliser materials. Report for Defra Project NT 2603 (CSA 6354).
Watson, C.J., Laughlin, R.J. and McGeough, K.L. (2009). Modification of nitrogen fertilisers using inhibitors: Opportunities and potential for improving nitrogen use efficiency. Proceedings 658, International Fertiliser Society, York, UK. 1- 40.

A3: Biological nitrogen fixation in grass clover swards

Managed grass/clover swards lower the requirement for chemical fertiliser N inputs due to the nitrogen fixing ability of white clover. Well managed grass clover swards can produce similar DM yields to pure grass swards receiving 150kg fertiliser N per ha. (Frame and Laidlaw, 2011).

Dawson et al (2009) estimated that adoption of grass/clover swards could reduced GHG emissions by up to 19% per kg carcass weight of beef, compared to a grass-based system using 150kg chemical N/ha.

References: Dawson, L.D. et al (2009) Greenhouse gas emissions and carbon footprint of beef production systems. In “From Beef Production to Consumption – A Seminar for Specialists” October 2009. Proceedings of an AgriSearch Seminar.
Frame, J. and Laidlaw, A.S (2011) Improved Grassland Management, Crowood Press Ltd, Wiltshire p 279.

A4: Nutrient Management Plans.

See details at Annex 5.

B1: Sheep genetic improvement via OVIS

It is widely accepted that production systems which result in a lower animal age at slaughter and higher lifetime growth rates reduce carbon footprint per kg of carcass weight (Dawson et al 2009) Genetic selection for breeds, or strains within breeds, with higher lifetime growth rates therefore reduces carbon footprint. Similarly, increasing ewe productivity through higher number of lambs finished per breeding ewe reduces the carbon footprint of lamb production by spreading the GHG “cost” of maintaining a ewe over more lamb carcass weight.

References: Dawson, L.D. et al (2009) Greenhouse gas emissions and carbon footprint of beef production systems. In “From Beef Production to Consumption – A Seminar for Specialists” October 2009. Proceedings of an AgriSearch Seminar.

B2: Beef and dairy cattle genetic improvement via BOVIS

As with sheep systems highlighted above, production systems with higher lifetime growth rates reduce carbon footprint per kg of carcass weight. Dawson et al (2009) demonstrated that the carbon footprint of intensively finished bulls (slaughtered at 16 months) was 43% lower than that of steers on a forage-based system finished at 25 months. Consequently, genetic selection for increased lifetime growth rate and/or increased cow productivity (eg better fertility) will reduce C footprint per kg of carcass weight. In dairy systems, Woods et al (2010) estimated that an improvement in dairy herd fertility reflected in a reduction in annual culling rate from 28% to 20% could result in a 6% reduction in GHG emissions per litre of milk.

References: Dawson, L.D. et al (2009) Greenhouse gas emissions and carbon footprint of beef production systems. In “From Beef Production to Consumption – A Seminar for Specialists” October 2009. Proceedings of an AgriSearch Seminar.

Woods. V.B. et al (2010) Calculating the greenhouse gas footprint of dairy systems: a preliminary analysis of emissions from milk production. In “Improving the Sustainability of Dairy Farming Within Northern Ireland” October 2010 Proceedings of an AgriSearch Seminar.

B3 Nutritional analysis of feed

Dietary changes to enhance the efficiency of feed can also reduce the carbon footprint of milk/meat production by up to 10% (Yan and Mayne, 2007). Dietary strategies include: increasing dietary ME and crude protein concentration or increasing the proportion of concentration in the diet. Other research (Taminga et al 2007) indicates that concentrate type eg those containing low sugar and high levels of rumen resistant starch can reduce methane output by up to 5% per kg milk. Inclusion of lipid supplements with high levels of polyunsaturated fatty acids can significantly reduce methane emissions (between 27 and 37% reduction), with no effect on overall animal performance (Martin et al, 2007).

References: Yan, T. and Mayne, CS (2007) Mitigation strategies to reduce methane emission from dairy cows. In High Value Grassland: Providing Biodiversity, A Clean Environment and Premium Products. Proceedings British Grassland Society.

Taminga et al (2007) Feeding Strategies to Reduce Methane Loss in Cattle. Report No 34 Animal Science Group Wageningen DR.

Martin et al (2007). Rumen methanogenesis of dairy cows in response to increasing levels of dietary linseeds. Proceedings 2nd International Symposium on Energy and Protein Metabolism and Nutrition 9-13 September, 2007 Vichy, France.

B4: Targeting waste as a result of disease – BVD

BVD has a number of negative effects on the productivity of cattle herds including: slow growth rates; susceptibility to other diseases; increased mortality rates; and decreased calving rates (Stott et al 2010). A reduction in disease incidence or elimination of BVD in cattle herds in Northern Ireland would therefore reduce GHG emissions per kg meat and milk.

Reference: Stott et al (2010). An analysis of the effects of BVD eradication in Scotland: A farm business level impact assessment. Paper for Scottish Government.

C1: Slurry based on farm AD vs traditional dairy manure management

Production of “renewable” energy from farm and forestry derived biomass, in the form of slurry, manure, forest brash, energy crops etc can help to reduce fossil fuel use on farms although, under current rules, reductions in fossil fuel use are not credited within the agriculture inventory.

Nonetheless, recent results (Frost and Gilkinson, 2011) indicate that anaerobic digestion of dairy cow slurry increases nitrogen availability in digestate by up to 19% compared with raw slurry. The improved nitrogen availability of digestate should improve the fertiliser value of this material relative to raw slurry, thereby facilitating a reduction in chemical N fertiliser use.

References: Frost, J.P. and Gilkinson, S. (2011). Interim Technical Report. Twenty Seven Months Performance Summary for Anaerobic Digestion of Dairy Cow Slurry at AFBI Hillsborough.

C2: Installation of Biomass Boilers. See details at Annex 5.

Annex 4

C3: Land utilisation to grow energy crops

Grogan and Matthews (2006) have shown that the potential for soil C sequestration in short rotation coppice (SRC) plantations is comparable to that of naturally regenerating woodland, accounting for up to 5% of the overall carbon mitigation benefit arising from SRC plantations. Soil carbon sequestration is greatest in soils with a depleted carbon content due to land practices such as annual deep ploughing.

References: Grogan, P. and Matthews, R. (2006). A modelling analysis of the potential for soil carbon sequestration under short rotation coppice willow bioenergy plantation. Soil Use and Management 18: 175-183.

C4: Optimise energy use on-farm. See details at Annex 5.

D1: Locking in carbon in grass and soil

Grassland represents an important sink for C in Northern Ireland, although there is considerable uncertainty regarding the impact of grassland management strategy on longer term sequestration level. Recent research in France (Soussana et al, 2009) concluded that grassland C sequestration had significant potential to partly mitigate the GHG balance of ruminant production systems, with annual C sequestration of 129, 98 and 71gC/m² for grazed, cut and mixed grassland system.

References: Soussana, J.F., Tallec, T. and Blanfort, V. (2009). Mitigating the greenhouse gas balance of ruminant production systems through carbon sequestration in grasslands Animal 4:334-35.

D2: Locking in C in peatland (sequestration)

Peatlands have an important role in carbon storage and given that 14% of land area in Northern Ireland is classified as peat land (Cruickshank, 1997), restoration of degraded peatland offers significant potential to increase C sequestration. Belyea and Malmer (2008) examined rates of C sequestration in peatland in southern Sweden and demonstrated historical rates of sequestration ranging from 14-72gC/m²/year, with the higher rates associated with wetter conditions (water table closer to the surface).

References: Cruickshank, J.G. (1997). Soil and Environment Northern Ireland. Agricultural and Environmental Science Department, The Queens University of Belfast. Belyea, L.R. and Malmer, N. (2008). Carbon sequestration in peatland: patterns and mechanisms of response to climate change. Global Change Biology: 10:1043-1052. A compendium of UK peat restoration and management projects. Defra Research Project (2008) Peatlands and Carbon – a critical synthesis Richard Lindsay, RSPB Report (2010).

D3: Locking carbon in new woodland biomass

Locking carbon (sequestration) in new woodland (both biomass and soil carbon) and abatement through wood substituting for fossil fuels represents the most effective approach to Green House Gas (GHG) abatement.

- Different woodland types have different establishment costs and different emission abatement potential. Abatement for different woodland types range between 5 and 15 tCO2 per ha per year.
- Impacts of climate change on tree productivity, tree condition, woodland soil storage potential may affect the ability of woodland to sequester carbon in the future.

References: The Read Report 2009. Read, D.J., Freer-Smith, P.H., Morison, J.I.L., Hanley, N., West, C.C. and Snowdon, P. (eds). 2009. Combating climate change – a role for UK forests. An assessment of the potential of the UK's trees and woodlands to mitigate and adapt to climate change. The Stationery Office, Edinburgh.

D4: Managing existing woodland to deliver GHG abatement.

Managing existing woodland to deliver GHG abatement.

- There is limited scope for changes in forest management alone to deliver significant changes in levels of GHG abatement and woodland creation should be the initial focus.
- Optimising timber production in appropriate woodlands offers a small opportunity to increase GHG abatement.
- Maintaining the forest area by protecting it from pests, disease and abiotic damage secures existing GHG abatement.

References: The Read Report 2009. Read, D.J., Freer-Smith, P.H., Morison, J.I.L., Hanley, N., West, C.C. and Snowdon, P. (eds). 2009. Combating climate change – a role for UK forests. An assessment of the potential of the UK's trees and woodlands to mitigate and adapt to climate change. The Stationery Office, Edinburgh.

Case Study A

Research Tackling Climate Change

Methane and nitrous oxide emissions from Northern Ireland farms account for almost 17% of our total greenhouse gas (GHG) emissions.

Research at AFBI is investigating options to help the NI agricultural industry reduce its carbon footprint and mitigate the effects on climate change. The main priority areas are:

1. Improving technical efficiency to reduce enteric methane emissions from ruminants.
2. Identifying strategies to reduce nitrous oxide emissions from fertilisers and soils.

Sustainable dairy systems

Research is underway to calculate the GHG footprint per litre of milk across a range of different milk production systems. The ‘carbon calculator’ will encompass all sources of GHG including enteric fermentation, manure management, fertilizers, soils and energy consumption.

This information is also being used to identify mitigation strategies to help reduce carbon footprint.

Suckler beef systems

AFBI’s Bovine Information System (BovIS) is being developed to provide tools to assess suckler cow fertility and to monitor changes in the growth and carcass quality of beef cattle within and between years.

Methane emissions and production efficiency of contrasting suckler cow types (maternal beef breeds versus crossbreds from the dairy herd) are being assessed at AFBI Hillsborough. This work will help shape future breeding strategies for the NI beef industry.

Case Study A

Sheep systems research

Novel ewe and ram genotypes are being developed and evaluated on twelve hill and lowland flocks throughout Northern Ireland. These breeds have been developed to maximize lamb output while reducing methane emissions and labour inputs.

A new centralised database (Ovine Information System, OvIS), integrating data from APHIS with commercial industry data, is under development. This tool will enable lamb growth and carcass characteristics to be monitored on a near real-time basis.

Nutrient management

Agriculture in Northern Ireland accounts for almost 80% of nitrous oxide (N_2O) emissions, mostly arising from agricultural soils and livestock manures. Nutrient management strategies are being investigated to reduce nitrous oxide emissions following land application of nitrogen fertilisers.

The potential of amending urea (with a urease inhibitor) as a fertiliser to replace calcium ammonium nitrate (CAN) is being studied to determine its effect on N_2O emissions and sward production.

The research at AFBI is being co-ordinated by world-leading scientists. Collaboration with other research centres in the UK and Ireland also helps to ensure that the NI agri-food sector benefits from international expertise.

Case Study B

Greenhouse Gas Inventory Research Contracts

New research will help farmers reduce greenhouse gas emissions

DEFRA is funding a series of three major research projects over the next four and a half years, which will improve our understanding of how agriculture contributes to climate change through the emission of greenhouse gases (GHG), and how these emissions might be mitigated. Agriculture in Northern Ireland contributes about 23 per cent of all Northern Ireland greenhouse gas (GHG) emissions, but the way farming emissions are calculated fails to take into account the differences between different farming practices or the effects of innovative approaches and new policies that aim to reduce GHG emissions. This research will help us to understand these differences and give farmers the evidence needed to take more effective steps to reduce emissions.

The Agri-Food and Biosciences Institute (AFBI) is the Northern Ireland partner in this £12.6m research programme which involves 16 research groups across the UK and which aims to provide information which is specific to each of the devolved administrations as well as to the UK as a whole. The funding for this work is coming from DEFRA along with contributions from DARD and the other devolved administrations.

AFBI will contribute sets of data relating to methane emissions from housed livestock and nitrous oxide emissions from soils which will be collated into a comprehensive UK wide database of current knowledge on GHG emissions. However, it is already known that many aspects of GHG emissions from soils, fertilizers, manures and livestock are poorly understood. Research will therefore be undertaken to provide more detailed data regarding GHG emissions from soils at a range of sites across the UK, including one in Northern Ireland, and from livestock groups such as grazing dairy and beef animals, dry cows, lowland and upland sheep. The research being undertaken by the Agriculture and Agri-Environment Branches of AFBI will be based at AFBI Hillsborough and at Newforge Lane.

Case Study C

An integrated approach to tackle climate change.

DARD's Research Challenge Fund (RCF) is providing a unique opportunity for the public and private sectors to collaborate in tackling climate change.

DARD and AgriSearch have joined forces to help quantify greenhouse gas (GHG) emissions from dairy and beef herds in Northern Ireland. Working alongside AFBI scientists and a dedicated team of farmers throughout the Province, this research is also seeking to identify management strategies to help reduce emissions.

Sustainable dairy systems

Online tools, integrating data from AFBI's BovIS database with production and feed records, are being developed to enable dairy producers to calculate their carbon footprint. This information is also being used to investigate the factors which influence GHG emissions, such as conception rate and age at first calving.

The 'carbon calculator' will be put to the test on 10 dairy farms around Northern Ireland, representing a wide range of production systems. A range of dry-cow management strategies are also being investigated for their impacts on cow health, performance and GHG emissions.

Sustainable beef systems

Online tools based on AFBI's BovIS database are being developed to enable beef producers to calculate their carbon footprint with the minimum need for additional record keeping.

This information is being used to develop 'blueprints' for beef production systems with a reduced carbon footprint. These blueprints are being evaluated with the help of 12 beef producers around Northern Ireland.

Annex 5

Implementation Measures

Nutrient Fertiliser management:	A1. Slurry application by trailing shoe
	A2. Timing of slurry application
	A3. Nitrogen fixation in grass/clover swards
	A4. Nutrient Management Plans
Better Livestock management:	B1. Sheep genetic improvement via OVIS
	B2. Beef and dairy cattle genetic improvement via BOVIS
	B3. Nutritional analysis of feed
	B4. Targeting waste e.g. as a result of BVD
Renewable Energy and Fuel efficiency on farm:	C1. Slurry based AD
	C2. Biomass Boilers
	C3. Land utilisation to grow energy crops
	C4. Optimise energy use on farm
Locking in Carbon:	D1. In grass and soil
	D2. In peatland
	D3. In new woodland
	D4. By managing existing woodland

Annex 5 - Implementation Measures (Cost savings and GHG Reductions quoted are optimal)

Mitigation Measures

The following tables set out the agreed prioritised mitigation measures to be communicated on a sector basis:

Dairying	Beef / Sheep	Arable
Mitigation Measure	Mitigation Measure	Mitigation Measure
B3 – Improving feed efficiency	B1 / B2 – Genetic improvement	A4 – Nutrient Management Planning
A4 – Nutrient Management Planning	B3 – Improving feed efficiency	C4 – Energy Efficiency
A1/A2 – Timing and Application of slurry	B4 – Targeting waste as a result of disease - BVD	B1 – Plant genetic Improvement
B2 – Genetic improvement	A3 – Grass / clover swards	A1/A2 – Timing and application of slurry
C4 – On-farm energy efficiency	A1 / A2 -Timing and application of slurry	D3/D4 – Creation of new and management of existing woodlands
A3 – Grass / clover production		

Annex 5

Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Better Nutrient and Fertiliser Management					
A1 Slurry Application via Trailing Shoe vs Splash Plate. (Trailing shoe is placing slurry in narrow line on the ground). Slurry applied by trailing hose or injection systems also have significant savings.	Manure N efficiency increased to 39%. Better grass yield (+26%) kg DM/ha. Less need for chemical fertiliser/ reduced input costs. 44kg N per ha fertiliser N saving for each slurry application of about 50m3.	Chemical fertiliser savings: - savings equivalent to £44 per ha per application if CAN is £270 per tonne. - 4.1 tonnes less fertiliser per year for each 100 dairy cows or £1107 per 100 dairy cows. Cost savings will vary if contractor charges more for spreading by this equipment. Cost savings will also vary depending on the specification of equipment used.	Reducing chemical N fertiliser use lowers GHGs by up to 535 kg CO_2 eq per 50m3 of slurry applied. 30% usage of TS across NI = CO_2e saving of 43 kt.	Capital cost up to £10k (40%) toward cost of equipment via METS. Free demo events held by CAFRE on benefits of equipment.	Minimise ammonia loss by as much as 60%. Manure N efficiency increased to 40%. Therefore less chemical N fertiliser needed for same crop yield. Potential for improved water quality due to less contamination of runoff. Public benefit – reduced odour and reduced visibility of operations in fields. Reduced grass contamination allowing wider window to spread during the growing season – grass does not have to be very short when spreading. Allows higher total application rates on individual fields - important for intensively stocked farms. Allows grazing earlier following application. Narrower buffer strips allowed adjacent to watercourses therefore more productive area.

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Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Better Nutrient and Fertiliser Management					
A2 Timing of Slurry Application by splash plate - time of year. - mixing of organic and chemical fertiliser. - type of chemical fertiliser used in wet conditions.	Lower ammonia emissions from early season spreading. More N available to the crop when slurry applied in spring (Feb – Apr) compared to summer and autumn. Lower N_2O emissions if slurry is spread at least 3-4 days before a nitrate containing fertiliser. Lower N_2O emissions when ammonium instead of nitrate based fertilisers are applied under wet conditions.	More N available from slurry therefore less chemical fertilizer required. Potential saving of up to 5% of the nitrate component of the fertiliser (average over the year 2.9%). Too small an effect to be realised in dry-matter yield.	Reducing chemical fertiliser reduces N_2O emis-sions from its pro-duction and use Up to threefold decrease in N_2O emissions when ammonium based fertilisers are applied instead of CAN under wet conditions.	Easy to follow. Increases manure N efficiency and therefore reduces requirement for chemical fertilizer purchases.	Application of manures during periods of increased crop requirement (March-June) will result in lower emissions compared to applications later in the year.

Annex 5

Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Better Nutrient and Fertiliser Management					
A3 Biological nitrogen fixation in grass / clover swards.	Managed grass/clover swards lower the requirements for chemical fertiliser N inputs.	Saving in CAN fertiliser at £270 per tonne.	Lower (direct) emissions due to reduced spreading of chemical N fertiliser. Lower (indirect) emissions associated with fertiliser N manufacture. GHG emissions from grass/clover systems can be 12 – 23% lower than from grass/ fertiliser systems (Teagasc data).	Similar dry matter yields from grass/clover Vs grass only that receives chemical N fertiliser at 150kg N per ha.	Biological fixation of atmospheric N, reduces the need for chemical N fertiliser. The same level of profitability can be achieved at lower stocking densities (Teagasc data). Lower stocking densities also result in lower methane emissions. The lack of persistence of clover in grassland swards can be a problem and requires careful management.

Annex 5

Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Better Nutrient and Fertiliser Management					
A4 Nutrient Management Plans. Accurate measurement of manure N content. Matching nutrient supply to crop requirements. Major nutrients (N, P, K, S) need to be in balance. Use of nitrification inhibitors to maintain ammonium-N in soil for longer.	Better efficiency of manure N use. Increases the efficiency of crop N recovery and hence lowers N_2O losses. Good crop response to N as long as other nutrients, particularly K & S are not limiting. Soil and plant analysis important.	Saving in CAN fertiliser at £270 per tonne. Could be wasting N fertiliser if K & S are sub-optimal. Cost benefit of nitrification inhibitors in N.I. not yet known.	Reduce N_2O from manure and chemical N fertilisers (49% reduction estimated in EU).	Fertiliser manuals and online calculators available. Nutrient Management training available.	Improved efficiency of manure N and chemical fertiliser N use, so lower losses to environment.

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Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Better Livestock Management					
B1 Sheep Genetic Improvement via OVIS: - increase growth rate. - increase ewe productivity.	Increased growth rate by 10% resulting in reduced days to a fixed slaughter weight. Increase ewe productivity from 1.28 to 1.35 through reducing the proportion of unproductive ewes and improve lamb survival.	Replacement costs. Productivity from existing stock.	Animals emit methane for a shorter time period.	Cost saving. Education and training available. Ovis data on each animal allowing informed selection (reproductive performance, growth performance, longevity, genetic background, benchmarking). Build on EID system requirements.	More resilient animals with good genetic history.

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Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Better Livestock Management					
B2 Beef and dairy cattle genetic Improvement via BOVIS: - increase growth rates. - increase cow productivity.	- genetic improvement for beef traits of 20%. - increase in cattle participating in genetic improvement programme by X %.	Replacement costs. Productivity from existing stock.	Animals emit methane for a shorter time period.	Cost saving. Education and training available.	More resilient animals with good genetic history.
B3 Nutritional Analysis of feed: - beef cattle rationing model. - dairy cattle rationing model.	Match best rationing model to lowest GHG emissions. Build on H'Borough Feed Information Service.	Increased yield from same number animals.	Exact savings yet to be determined but higher yield and less replacements will reduce GHG per kg or litre of product.	Education and training programme.	More from less.

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Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Better Livestock Management					
B4 Targeting waste eg. as a result of disease –BVD - reduced longevity - reduced efficiencies	As tools and knowledge are available eradication of BVD by end of year 3.	Decrease replacements Productivity yield increases.	Less replacements = less GHGs More yield per animal = less GHGs per kg or litre.	AFBI Cattle Health Scheme offers testing and certification (Blood and milk samples used for Br testing could be used, also milk samples collected for milk recording, also ear tissue samples are already collected.)	Better animal health Improved competitiveness

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Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Renewable Energy and Fuel Efficiency On-farm					
C1 Slurry based on-farm AD Vs traditional dairy farm waste management system i.e. tank/liquid separator/ land spread. (400 cow farm pro-ducing 19.7 tonne of slurry per day)	Reduced input costs Better used of slurries / grass Chemical fertiliser substitution.	Savings on energy purchased (electricity / heat / hot water) 1 tonne of dairy cow slurry = 8 Lts of diesel oil Saving on chemical fertiliser purchased at £270 per tonne as digestate is a fertiliser 1 tonne dairy cow slurry (7.2% DM can produce 57.8 kwh net heat.	Carbon minus 61% Vs tank storage system Methane minus 90% Vs tank storage system.	Up to £360k (40%) towards cost of installation via BPC Fund Planting grant to SRC. (NIRDP) ROCS available for electricity generation.	Replace fossil fuel by creating own energy (biogas) from sustainable biomass feedstock

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Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Renewable Energy and Fuel Efficiency On-farm					
C2 Installation of biomass boilers fuelled by woodchips or pellets to produce heat.	Reduced input costs. Better use of forestry and sawmill residues.	Savings on energy purchased (oil) to produce heat Revenue stream from brash sold to energy market. Revenue stream from forestry thinnings and sawmill arisings sold to energy market.	350kg of CO_2 if using oil per MWh Vs 25 kg of CO_2 if using bio-mass (woodchip) per Mw hour.	Up to £360k (40%) towards cost of installation via BPC Fund Planting grant for SRC willow. (NIRDP) ROCS available if using gasification for electricity.	Displace fossil fuel by creating own energy from sustainable biomass feedstock Increased woodland cover for bioenergy production. (Sequestration of carbon is better suited to enduring tree species) Biodiversity increases Reduced imports of woodchip product Increased energy security by producing your own energy (heat or heat and electricity) Better resource management

Annex 5

Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Renewable Energy and Fuel Efficiency On-farm					
C3 Land utilisation to grow energy crops e.g. SRC or grass for AD utilisation.	Smarter land use (not at expense of established use for food production or grass for silage). Minimal disturbance of soil when planting e.g. grass seed drilling. (New techniques to plant SRC without releasing soil carbon.	Create revenue stream from currently unproductive land.	Locking in Carbon even in short lifespan of SRC. Biomass to replace fossil fuel.	Planting grant for SRC Willow available (NIRDP).	Displace fossil fuels with sustainable biomass feedstock. Minimise soil disturbance. Improved biodiversity in SRC plantations.

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Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Renewable Energy and Fuel Efficiency On-farm					
C4 Optimise energy use on-farm - raising awareness via fuel efficiency courses - energy audits on farm to match usage to appropriate tariff benchmarking energy efficiency (average per dairy cow £37, high £58, low £15)	Reduced requirement for fossil fuel Improved tractor efficiency. Transfer to lower cost tariff. Installation of energy efficient technologies e.g. plate coolers, time clocks, lights, insulation. Training attendees carry out benchmarking (500 to be benchmarked by 2012).	Energy efficiency of £5.7m identified by CT in 2007. From data collected from course attendees so far, 30% of dairy trainees saved £160 pa each, 40% of mushroom trainees saved £2,500 pa each, 39% of pig trainees saved £9,500 pa each.	CT 2007 identified 34,500 tonnes of CO_2e if £5.7m realised. In 08/09 465 tonnes of CO_2e were saved by trainees adopting measure. In 09/10 800 tonnes of CO_2e were saved by trainee adopting measures.	Free training from CAFRE. Financial savings. Improved environmental credentials in market place.	More competitive business Less reliance of fossil fuel More aware of alternative approaches to energy on the farm, including renewables.

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Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Locking in Carbon (Sequestration) in grass/soil and Peatland					
D1 Locking in carbon in grass and soil (sequestration) Permanent grassland removes CO_2 from the atmosphere in above ground growth and within the soil.	Carbon sequestration intake is influenced by climate, plant communities, grazing animals, management and soil type. Potential for grassland sequestration - actual contribution land is making - potential for land to act as a sink for carbon.	Before cost savings can be calculated: - research is required to provide knowledge about how grassland management could be modified to contribute to mitigating CO_2 emissions. - confirmation of high C sequestration rate by grassland could reduce C footprint of locally produced ruminant products.	If no disturbance (e.g. cultivation) sequestration rate average is 1.2 tonnes C/Ha/ annum However, little is known about carbon dynamics of grassland under grazing / hay / silage managements The effect of grassland age on sequestration needs to be quantified since there is some evidence of C 'saturation' with time.	AE schemes include options on grass margin creation on arable land and low input options to reduce inputs and enhance Carbon sequestration from by not disturbing land.	Land removed from agriculture when creating margins through A-E schemes. Grass margins enhance biodiversity, provide corridors for movement of wildlife, provide food for a range of farmland birds and mammals and may act as a sink for carbon storage by leaving soil undisturbed. There is also a reduced input of C through reduced machinery use and fertiliser application. Targeting areas which have organic rich soils may increase benefits.

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Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Locking in Carbon (Sequestration) in grass/soil and Peatland					
D2 Locking in C in peatland (Sequestration). Restoration of degraded peatland by measures such as: - blocking drains to encourage organic accumulation. - planting bare peat. - cessation of burning would have some positive benefits.	Peatlands restored (having been degraded by drainage in the past). Reduced burning of heather to - reduce C emissions. - decrease loss of organic matter in the top soil.	Although no cost savings have been produced it is obvious that some activities e.g. restoration or rewetting of cultivated deep peat would deliver higher cost benefits when compared to current land use activities.	Restoration may be repaid by the value of emission reductions over a 40 year period (Lindsay, 2010).	AE Schemes SEP options available (current AE heather management permits cleaning out sheughs / drains and may require amendment).	Peat land restoration restores peat land habitat; increases its value for biodiversity, enhances ecosystem service value and increases stability to Climate Change.

Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Locking in Carbon (Sequestration) in grass/soil and Peatland					
D3 Locking carbon (sequestration) in new woodland (both biomass and soil carbon) and abatement through wood substituting for fossil fuels represents the most effective approach to Green House Gas (GHG) abatement. -Different woodland types have different establishment costs and different emission abatement potential. Abatement for different woodland types range between 5 and 15 tCO_2 per ha per year. - Impacts of climate change on tree productivity, tree condition, woodland soil storage potential may affect the ability of woodland to sequester carbon in the future.	Government forest policy seeks to double forest cover in NI from current 6% (86,000ha) to 12% (172,000ha) between 2006 and 2056. (1,720 ha per annum on average needed to achieve this by 2056).	Cost effectiveness of abatement through new woodland creation varies for different woodland types and ranges between £-60.8/tCO_2 for Short Rotation Forestry (most cost effective) to £72.7 for YC 6 broadleaf farm woodland (least cost effective).	Doubling woodland would increase carbon sink from 0.54 to 1.09 $MtCO_2e$ Potential to offset up to 12% CO_2 emissions from agriculture.	Woodland Grant Scheme and Farm Woodland Premium Scheme administered by Forest Service AE Schemes currently fund tree planting for areas up to 0.2ha. Hedge planting also available under AE Schemes.	Wood production for timber to substitute for more energy intensive materials such as concrete and steel. Wood production for biomass to substitute for fossil fuels. Production, transport and processing wood in NI generate economic activity. Woodlands are places which people can enjoy and improve their health and wellbeing. Woodlands can provide habitat to maintain and enhance biodiversity. Woodlands can protect soil and water quality. Woodlands can alleviate flooding by delaying and reducing the size of the flood peak.

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Measure	Expected Impact	Cost saving	GHG reduction	Incentive	Production/Environment benefit
Locking in Carbon (Sequestration) in grass/soil and Peatland					
D4 Managing existing woodland to deliver GHG abatement. -There is limited scope for changes in forest management alone to deliver significant changes in levels of GHG abatement and woodland creation should be the initial focus. - Optimising timber production in appropriate woodlands offers a small opportunity to increase GHG abatement. - Maintaining the forest area by protecting it from pests, disease and abiotic damage secures existing GHG abatement.	Government forest policy seeks the sustainable management of all existing woods and forests.	Secured through existing management and hence cost neutral.	Maintains existing carbon sink of 0.52 $MtCO_2e$.	Felling and regeneration of trees regulated by the Forestry Act (Northern Ireland) 2010. Change of land use from forest to an alternative land use is subject to the Environmental Impact Assessment (Forestry) Regulations (Northern Ireland). Incentive to manage existing woodland available under the Woodland Grant Scheme.	Wood production for timber to substitute for more energy intensive materials such as concrete and steel. Wood production for biomass to substitute for fossil fuels. Production, transport and processing wood in NI generate economic activity. Woodlands are places which people can enjoy and improve their health and wellbeing. Woodlands can provide habitat to maintain and enhance biodiversity. Woodlands can protect soil and water quality. Woodlands can alleviate flooding by delaying and reducing the size of the flood peak.

Annex 6

GHG Stakeholder Group

- CNCC
- CONFOR
- DAIRY UK
- DARD
- IAP
- LMC
- NIAPA
- NIGTA
- NIMEA
- UFU