Market Segmentation in the Agriculture Sector: Climate Change

Prepared for: Climate Change Mitigation Team for Agriculture
Defra
Area 5C,
9 Millbank
c/o Nobel House
17 Smith Square
London
SW1P 3JR

Prepared by: ADAS UK Ltd
Woodthorne
Wergs Road
Wolverhampton
WV6 8TQ

Date: October 2010

0936648

Suggested citation for this report

Barnes, A.*, Beechener, S., Cao, Y., Elliott, J., Harris, D., Jones, G., Toma, L.* and Whiting, M. (2010). FF0201: Market segmentation in the agriculture sector: climate change. Final report to Defra.

*SAC, West Mains Road, Edinburgh, EH9 3JG

Acknowledgements

The authors would like to thank Defra for funding this work and the members of the Project Steering Group for their guidance and support throughout. In particular we would like to thank Max Petrokofsky, Shaun McLennan, Olawale Ladapo, Tony Pike, Caryl Williams and Kate Morley.

The support of participating farmers in the project workshops and interviews and of industry representatives at the Industry Day is gratefully acknowledged.

The team would also like to thank ADAS specialists Prof. Brian Chambers, Dr. Daniel Kindred, Dr. Bruce Cottrill and Susan Twining for their technical input on aspects of greenhouse gas emissions.

Abbreviations & Glossary

Term	Explanation
AD	Anaerobic digestion or digester
AHDB	Agriculture And Horticulture Development Board
AIC	Agricultural Industries Council
Anaerobic	Bacterial processes carried out in the absence of oxygen
BMP	Best Management Practice
Biofuel/biomass crops	Crops grown to replace fossil fuel energy
CLA	Country Land And Business Association
COGAP	Code of Good Agricultural Practice
CSF	Catchment Sensitive Farming
ECSFDI	England Catchment Sensitive Farming Delivery Initiative
DairyCo	The levy body for the dairy industry
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
Digestate	End product of anaerobic digestion
EA	Environment Agency
EBLEX	English Beef And Lamb Executive
EBV	Estimated Breeding Value (total score of a range of breeding traits)
ES	Environmental Stewardship
Enteric fermentation	Bovine digestion giving rise to methane emissions
GHG	Greenhouse gas
GHGAP	Greenhouse Gas Action Plan
HGCA	Home Grown Cereals Authority
NE	Natural England
MM	Mitigation method
NFU	National Farmers Union
PLI	Profitable Lifetime Index (genetic potential of dairy cattle)
RSPB	Royal Society For The Protection Of Birds

Executive Summary

To help meet the targets of the Climate Change Act 2008, Defra commissioned a suite of projects aimed at achieving a greater understanding of the cost effectiveness of mitigation potential, the likely response of a range of farmers by farm type, size and segmentation and the delivery of advisory services in order to achieve improved uptake at an early date.

The aim of this project was to identify the most relevant farm types, sizes and behavioural segments and to identify the attitudes and motivations for uptake. Subsequently, the focus was on the drivers and barriers for additional uptake of low-carbon opportunities and recommendations for the most appropriate policy tools to use in order to achieve abatement targets.

Research design

Secondary evidence was used to identify priority farm sectors and mitigation methods (MMs) in co-ordination with other projects. The range of MMs included was drawn from projects, particularly AC0222, with the addition of four longer term MMs to test farmer reaction. Industry representatives were consulted to test assumptions and discuss the evidence base prior to running farmer workshops for each selected sector in relevant locations. The workshops attracted a good cross-section of farmers from the arable, dairy and grazing livestock sectors, broadly representative of the industry. These workshops provided key evidence on attitudes and motivations to GHG mitigation opportunities, including current levels of uptake and scope for future uptake. They also considered the main barriers to uptake and how these might be overcome. Farmers within each of the three sectors were characterised according to farm size, personal attributes and behavioural types using the Defra farmer segmentation model.

Key findings

There was a significant level of uptake of the MMs considered in the study, largely on economic grounds, with dairy and arable farms demonstrating greater engagement on efficiency grounds, due to their high reliance on purchased fertilisers and focus on output. In contrast, upland livestock farms use fewer inputs and are more remote from their end markets and they feel they have less to contribute by way of abatement. Further, livestock farmers feel that they are ruled by their situation (markets, weather and land) which may confound attempts to increase abatement.

Farmer attitudes to the MMs is summarised in Table ES1.

There was a broad spread of perceptions of the importance of climate change, but generally, a poor level of understanding of the issues in relation to farming beyond vehicle and energy emissions. The main drivers for uptake of MMs were economic, best management practice, markets and peer pressure/custom, but there were a number of significant barriers:

- Structural – policy, tenure, age
- Financial – perceived cost of implementation and lack of government support
- Educational – awareness and knowledge; requirement for advice and training, local demonstration or monitor farms
- Management – farmers felt they were often doing as much as they could, running the business took precedence and economic pressure in the industry provided resistance to change in terms of time and cost to implement
- Administration – complexity of the range of policy affecting farming, time taken for acceptance on schemes, dislike of regulation

Table ES1 Summary of level of support or rejection of MMs by farmers:

Mitigation method	Overall	Farm type			Farm size			Segmentation				
		Arable	Dairy	Livestock	Small	Med	Large	C	LC	P	MFB	CE
Use RB209, PLANET or similar to work out N to apply	✓✓	✓✓✓	×	××	×	×	✓✓	××	✓	×	✓✓	×
Calibrate your fertiliser spreader every year	✓✓✓	✓✓✓	✓✓	✓✓	✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓
Take into full account the amount of N supplied by manure	✓✓✓	✓✓✓	✓✓✓	✓✓	✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓
Measure soil N supply before deciding how much N to apply	×	✓	××	××	×	××	×	××	×	✓	✓	×××
Use precision farming techniques	×	×	××	××	××	××	✓	××	××	×	✓	✓
Avoid applying mineral N fertiliser before the crop starts growing in spring	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Avoid applying slurry / manure before the crop starts growing in spring	✓✓✓	✓✓	✓✓✓	✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Don't apply mineral N for at least 5 days after applying manure	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓	✓✓✓
Spread the application of mineral N over 2or 3 applications rather than just one application	✓✓✓	✓✓✓	✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓	✓✓
Don't apply mineral N for at least 5 days after heavy rain	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓✓	✓✓✓	✓✓	✓✓
Grow triticale	××	×××	××	×××	××	××	××	×××	×××	××	××	×××
Put your manure into an anaerobic digester either on farm or somewhere else	×××	×××	×××	×××	×××	×××	×××	×××	×××	×××	×××	×××
Determine exact nutrition requirements of the livestock from the desired level of production	✓✓	N/A	✓✓	×	✓	✓	✓✓	✓	✓	✓✓	✓✓	✓
Introduce clover – white for longer term leys, red for short term leys	✓✓✓	N/A	✓✓✓	✓✓✓	✓✓	✓✓	✓✓	✓✓✓	✓	✓✓✓	✓✓	✓✓✓
Dairy - Seek high Profitable Lifetime Index (PLI) of livestock	✓✓✓	N/A	✓✓✓	N/A	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Beef - Seek high Estimated Breeding Value (EBV) of livestock	✓✓✓	N/A	N/A	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Sheep – Seek to improve optimum productivity	✓✓✓	N/A	N/A	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Covering slurry tanks to reduce ammonia and secondary emissions	×××	N/A	×××	×××	×××	×××	×××	×××	×××	×××	×××	×××
Growth promoters (Ionophores) e.g. Monensin	××	N/A	N/A	××	××	××	××	××	×××	××	××	××

Some support ✓; good support ✓✓; strong support ✓✓✓; light rejection ×; moderate rejection ××; strong rejection ×××

C = Custodians; LC = Lifestyle choice; P = Pragmatists; MFB = Modern family business; CE = Challenged enterprises

Most farmers across all sectors did not see climate change as an important consideration in their business. Table ES2 shows that this is consistent for farm size and segmentation type, even where the uptake of MMs is relatively high e.g. Lifestyle choice farmers.

Table ES2: Summary of attitudes and behaviours

		Priority of climate change (majority)	Uptake of MMs
Farm type	Arable	Not very to fairly important	1 to 10
	Dairy	Not very to fairly important	4 to 9
	Livestock	Not very to fairly important	2 to 10
Farm size	Small	Not very to fairly important	1 to 8
	Medium	Not very to fairly important	2 to 8
	Large	Not very to fairly important	5 to 10
Segmentation	Custodian	Not very to fairly important	2 to 8
	Challenged business	Not very to fairly important	4 to 9
	Lifestyle choice	Not very to fairly important	8 to 9
	Modern family business	Not very to fairly important	6 to 10
	Pragmatist	Not very to fairly important	5 to 9

Table ES3 summarises the range of solutions that emerged from the workshop.

Table ES3: Summary of barriers and means of overcoming them

Barrier	Size	Solution (from workshop discussions)	Estimated cost
Policy complexity, language and style	✓✓✓	Action required by Defra policymakers to formulate joined up policy and easy to access schemes	✓
Timescale for farmer uptake	✓✓✓	Subject to procedure & policy staff numbers	✓✓
Small farms	✓✓✓	Make additional allowances in policy	✓
Tenure	✓✓	Build in cancellation of long term support agreements	✓
Low margins/farm incomes	✓✓✓	Support levels for MMs need to reflect costs of implementation	✓✓✓
Demographics, age, succession	✓✓	Design of policy to accommodate these issues	✓
Knowledge	✓✓✓	Design of paper and electronic delivery systems	✓
Advice	✓✓✓	Design of telephone, one to one, group and demonstration and monitor farms	✓ to ✓✓✓
Contractors, trade, consultants	✓✓✓	Include in all areas along with farmers	✓
Staff turnover	✓	Dissemination of information on GHG issues and farming through e.g. press, Farming Futures	✓✓
Stock health	✓✓	Link to stock health policy	✓✓✓

Key:

1. Low cost: ✓ e.g. Defra own staff, production of leaflets
2. medium cost ✓✓ e.g. staff costs to deliver scheme through compliance visits
3. high cost ✓✓✓ e.g. financial support for MMs, 1:1advice with reports and follow up visits

The economic analysis in project AC0222 suggests that the priority sectors to target are the large farms across a number of robust farm types – *Dairy, Cereals, General Cropping* and *Mixed* – due to their size-related and sector-specific abatement potential. In addition evidence in this project (FF0201) suggests that most farmers are willing to consider abatement provided it does not impact negatively on the core business.

At the present time, no policy explicitly includes GHG abatement and awareness of low-carbon opportunities. However, actions could be delivered through the RDPE-funded vocational training scheme (measure 111) to help ensure farmers fully implement MMs that deliver a financial benefit. Other MMs requiring changes to management and financial input will require specific policy initiatives to deliver step change through advice and/or demonstration, using targeted approaches such as those used for Catchment Sensitive Farming (CSF) or Environmental Stewardship (ES). The cost of delivery of advice through a scheme to 5,000 farmers over 2 years might be £7.5m, or for five demonstration farms, £195,000 over a five year period.

Key barriers to be addressed include local applicability, the availability and development of markets and supply chain efficiencies from genetic improvement of livestock. These apply to a greater or lesser extent to the three MMs with the greatest abatement potential:

- Clover for extensive grazing
- Improved breeding in grazing livestock
- Low N crops

Policy aiming to engage a broad cross-section of farmers will need to utilise a range of levers in recognition of the attitudinal and behavioural differences that exist.

Contents

List of Tables

List of Figures

1. Introduction

1.1 Context for the study and related work

The 2008 UK Climate Change Act sets out a legally binding national commitment of reducing GHG emissions to 80% below 1990 levels by 2050. Following on from the Act, the 2009 UK Low Carbon Transition Plan provides a blue print for achieving this target. A carbon budget system has been established and each government department has budgetary obligations for their corresponding sectors. So far three budgets have been set for each of three different time periods, 2008-2012; 2013-2017; and 2018-2022.

Defra has already commissioned a significant amount of research regarding appropriate reduction targets and methods for fulfilling them. Projects to date have included formulating the UK marginal cost curves for agriculture, forestry, land-use and land-use change, delivered by the SAC (Defra, 2008b), an analysis of the policy instruments for reducing GHG emissions from agriculture, forestry and land management, delivered by ADAS (Defra, 2009b) and the subsequent 2010 Review and Update of the Marginal Abatement Cost Curve for Agriculture produced by the SAC and ADAS. These and other pieces of research have helped inform policy and establish the emissions target for the agricultural sector (as stated in the UK Low Carbon Transition Plan) which has been set at an average annual abatement sum of 3Mt CO_2e for the period 2018-2022.

This project is one of a suite of current Defra projects:

- AC0221: Scoping the potential to reduce GHG emissions associated with N fertiliser applied to arable crops
- AC0222: feasibility of Greenhouse Gas mitigation methods
- FF0202Providing appropriate knowledge transfer - Agricultural Advisory Services Analysis
- FF0201Market segmentation in the agriculture sector: climate change

They are aimed at achieving a greater understanding of the cost effectiveness of mitigation potential, the likely response of a range of farmers by farm type, size and attitude and the delivery of advisory services in order to achieve improved uptake at an early date

Evidence from recent work suggests a high degree of uncertainty in the levels of abatement possible from the MMs, the degree to which MMs have been taken up and their effectiveness in general terms Defra 2008a and Defra 2009a. This suite of projects is aimed at reducing much of that uncertainty and clarifying the differences across farm types and sizes.

1.2 Rationale and purpose for the study

To help the industry realise this target by most effectively directing advice and resources, it is essential that government gains a clear understanding of how the sector can be broken down with regard to issues surrounding climate change.

The project aims were defined as follows, to:

a. identify priority sectors for intervention so as to reduce emissions from the farming sector in a cost-effective way;
b. identify the main drivers and barriers to uptake of low-carbon opportunities in each sector;

c. quantify the size of barriers and if possible provide monetary estimates for each barrier identified;
d. identify / recommend high priority segments on which policy should initially focus and
e. provide costed, sector-specific recommendations on how to drive the process of cutting emissions.

The analysis takes into account behavioural segmentation to widen the range of policy levers that may be used for influencing uptake of abatement options.

2. Methodology

2.1 Scoping mitigation methods and sectors

The initial task was to identify which farm sectors and mitigation methods offered the best opportunity for securing GHG emission reductions. The approach taken is outlined separately for MMs and sectors, although there is inherent interdependence.

The mitigations methods used were based on those selected for study in the parallel project AC0222, to provide consistency between the studies. The selection criteria were:

- Is emission reduction achieved through sequestration and/or land use change?
- Is the emission reduction achievable across the agriculture industry?
- Is the emission reduction achievable within a reasonable timescale i.e. within the second and third carbon accounting budget periods
- Practicality
- Cost effectiveness below £53/t CO_2 by 2012
- Abatement potential greater than 50ktpa by 2012
- Abatement potential greater than 100ktpa by 2017
- Abatement potential greater than 150ktpa by 2022
- Policy relevance

In addition, the Project Steering Group asked for an additional three MMs which were considered 'more challenging' to be included:

- use of precision farming techniques,
- covering of slurry tanks and
- use of growth promoters if permitted.

The full list of MMs is detailed at Appendix 2.

The priority sectors in terms of farm type and size were selected on the basis that they represented a significant proportion of the industry and were likely to produce a large proportion of the emissions (NERA 2007). The analysis identified three sectors, dairy, arable and beef and sheep.

2.2 A segmentation approach to farmer attitudes and behaviours

Through understanding the attitudes and behaviours of farmers with regard to uptake of low-carbon opportunities, the aim was to identify high priority segments to target for best results in terms of emissions abatement.

By identifying key characteristics of farmers at the workshops and their attitudes and behaviours to low-carbon practices, any linkages were identified. These included:

- Age
- Gender
- Tenure
- Full or part time

- Length of association with current business

In addition, farmers were segmented by behavioural type, using a segmentation model (Defra, 2008b) based on individual farmer characteristics such as attitudes and motivations. These segments are broadly described as follows:

(i) Custodians – farming is a way of life;

(ii) Lifestyle choice – where farming is not the main source of income;

(iii) Pragmatists – a balanced approach to make a living;

(iv) Modern family business – ensuring succession to a viable business; and

(v) Challenged enterprises – isolation is an issue.

2.3 Drivers and barriers to uptake of low-carbon opportunities

The study used a largely qualitative approach to identify motivations and barriers for low-carbon practices. The primary research element of this study was based around engagement with a group of industry representatives (Industry Day) to scope and validate motivations and barriers to GHG mitigation and a subsequent series of focus groups (Farmer Workshops) to explore these in depth.

The Industry Day was held for a range of industry representatives from farming, environmental, trade and regulatory bodies[1] (details at Appendix 2) to draw on the experience of the industry to test assumptions with regard to the farming industry's awareness of and engagement with climate change abatement, attitudes to the available MMs, barriers to uptake and the most effective policy approaches to deliver abatement. In addition, details of other relevant initiatives were captured.

Three farmer workshops were held, one in each of the Government Super Regions, each focussed on one of the three target sectors in an area dominated by that farm type, as follows:

(i) Dairy - Bridgwater in the South West;

(ii) Arable - Bury St. Edmunds in the East; and

(iii) Grazing livestock – Skipton in the North

The workshops comprised of the following:

- an initial questionnaire, which enabled them to be stratified as set out in section 2.2,
- they were then asked how important they considered climate change in making farming decisions,
- they were then shown the list of MMs and asked which ones they currently implemented, to what extent and how often,
- an interactive presentation followed describing each MM in turn and gathering the farmers' level of knowledge and understanding, how they implemented individual MMs and the relevance of each one to the sector,

[1] Discussions were held via the telephone with those who could not attend.

- the list of MMs was then reviewed to capture any likely changes to implementation against a list of reasons for change that might follow in the light of greater knowledge,
- a case study farm was presented for each workshop relevant to the sector and used to discuss which MMs the farmers considered relevant and
- the final session was a debate about the drivers and barriers to uptake of MMs and what it might take to overcome them.

Costed plan

Following the workshops, a costed plan was put together, taking information from AC0222 on estimates the lower and maximum increase in uptake and the resulting GHG reductions. The total cost of implementing the MM and the cost per tonne of CO2e reduced are also included (a negative cost represents a positive return or profit for the farmer from implementing the MM). The following criteria were used to formulate a GHG reduction plan for the agriculture sector.

(i) Scale of mitigation: The degree to which farmers are likely to implement a MM will indicate whether it warrants targeting through a plan. Whilst some MMs may have potential, there will be lower limits to what is worth targeting individually or collectively in terms of abatement, timescale and both public and private costs. Different policy approaches will be considered whereby objectives may be delivered through existing policy tools or through a range of options at different cost levels.

(ii) Cost or benefit to farmer: Whether the MM in question is at a cost or provides a benefit to the farmer will require a different mechanism in the plan. If they are deemed cost beneficial but uptake is not sufficient, then evidence needs to be provided in a suitable format and through the correct channels. Advice on profitable farm management options should be provided through the market. Farm consultants, the trade and contractors may need to be targeted with the evidence as well as farmers.

(iii) Incremental or step change: Incremental change normally occurs during the initial uptake of an MM that does not involve significant changes to management so are normally carried out at little or no cost or in many cases, result in savings. A step change occurs with a significant change in management with or without investment, where costs will be higher. This may result in a cost per unit of abatement, savings or additional income. Examples of each are soil mineral nitrogen testing, improved genetics in breeding and anaerobic digestion. For some of the step change MMs, farmers would need more proof via research, demonstration and monitor farms. Some, for example, anaerobic digestion, may require substantial capital grants.

(iv) Fit with existing farm delivery mechanisms (private and public). Questions to address are how easily do the MMs fit into current programmes, method of delivery e. g. synergy with other policy e.g. CSF and ETIP and relationship with the RDPE Axis 1 where a number of advice schemes are currently delivered.

(v) Type of evidence required: The extent to which the MM already carried out by some; do novel MMs need additional proof of financial performance via research and/or demonstration – this fits with incremental/step since more proof required for step change

3. Results

3.1 Characterisation of workshop delegates

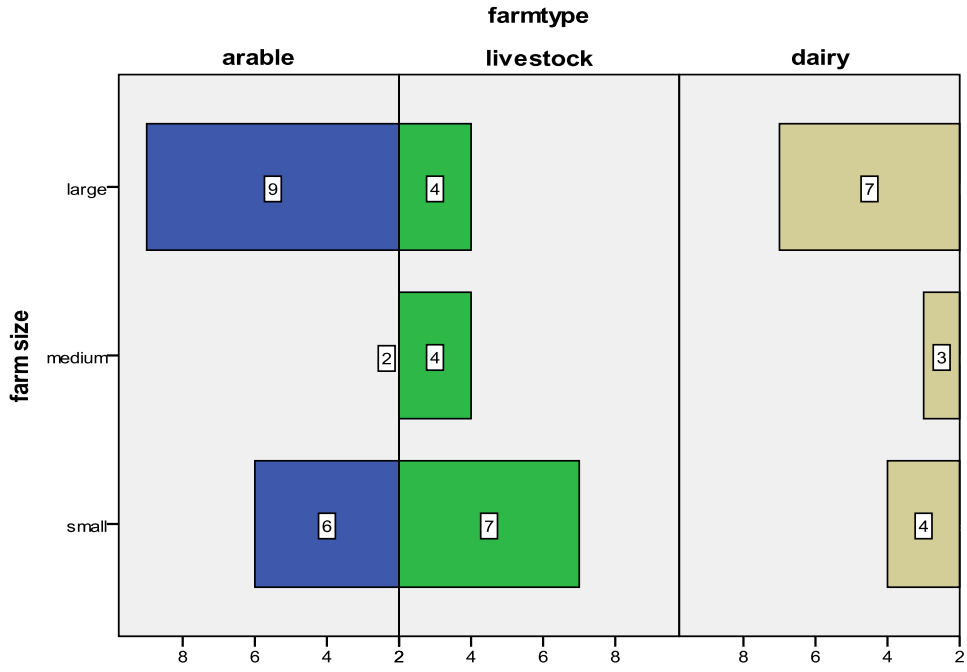
Recruitment of farmers to the workshops was challenging due mainly to the time of year (May is especially busy for farmers in terms of fieldwork) but also due to a disconnect from the topic in question. In addition to high resistance to attend, the low relevance and / or priority of low-carbon farming was evident from the workshop discussions. Despite this, when the reason for the workshop and their roles were explained, even the more sceptical showed some interest.

At the workshops, the response to the initial questionnaire revealed that the farmers knew little about GHGs emitted from their businesses apart from vehicle or energy emissions. However, it was clear that they were concerned to use resources carefully, due to the high cost of, for example, mineral fertilisers.

Farm size and type

In selecting the farmers businesses to attend the workshops, care was exercised to try to ensure an even number of small, medium and large businesses within each of the three farm types. The number of each type and size category is shown in figure 1 below. It is noticeable that there were more large and small farms than medium in all sectors. It was not clear why this was the case, but it may be that on medium sized farms there are greater demands on farmers' time than on a smaller farm, but there is not the ability to delegate to others that is often found on larger farms.

Figure 1: Distribution of farms by farm size and farm type



Farmer age and gender

The farmers attending the workshops represented a broad spread, but as may be expected, mostly mature men of long experience in the industry. The age of farmers might also be expected to influence attitudes to low-carbon practices. The distribution by age is shown in Table 1.

Table 1: The age of delegates at the farmer workshops and top-up telephone survey

Age group	Number	%	Defra*
<34 yrs	1	2%	3%
35 – 44	9	20%	12%
45 – 54	15	33%	23%
55 – 64	14	30%	29%
65 - 74	5	11%	33%
>75	2	4%	

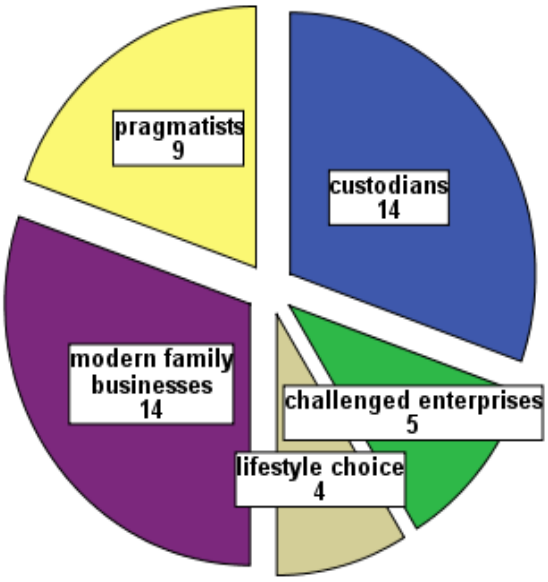
***Defra 2008 Agriculture in your pocket

In terms of gender, just two delegates at each of the arable and dairy workshops were women, which reflect a largely male-dominated industry.

Farmer behavioural type

In terms of behavioural type, there was generally a close correlation to the Defra farmer segmentation groups. Farmers were segmented at the workshops using a questionnaire at the start of the event and the distribution was close to that found in previous Defra studies (Figure 2).

Figure 2: Distribution of farms by segmentation type (count)



Farm tenure

With regard to tenure, the picture was mixed with most farms being part owner occupied and part tenanted. In the arable sector, many farms included contract farmed land. Whilst tenure on the livestock sector farms followed a similar pattern, half of them used contractors to apply fertiliser and other heavy fieldwork.

Reliance on farming and time in the business

All farmers were full time, although three did have additional off-farm employment. Farmers in the livestock workshop noted that many livestock farmers were part time, however and likely to be in farming because they enjoyed the lifestyle.

Most of the delegates had been associated with the business for many years (over 20). Where this was not the case, it was because they were too young and had been in the family business from the start of their career or they had moved from a previous position on a farm.

3.2 Attitudes to mitigation methods and potential uptake

Defra project AC0222 (Agricultural Greenhouse Gas Mitigation Feasibility Study, July 2010) produced estimates for mitigation potential for a similar group of MMs as considered in this study. In total, the proposed MMs represented between 17% and 44% of the Agriculture Industry GHG Action Plan (GHGAP)[2] emissions reduction target. Overall, these MMs are estimated to be cost beneficial when implemented. The three most significant MMs in terms of reduction potential are all cost beneficial (CPMM 7, 8 and 9 in table 2). However, four of the six fertiliser planning and application MMs have costs which outweigh the benefits for farmers to introduce (CPMM 2, 3, 5, and 6 in Table 2).

Table 2: Estimated GHG reduction potential (from AC0222)

CPMM	Total TCO_2e Reduced		Total Cost		Cost per TCO_2e	
	Lower	Max	Lower	Max	Lower	Max
1: Fertiliser planning, RB209	23,105	51,616	-£4.4m	-£10.9m	-£212	-£231
2: Estimate Soil N	18,695	34,057	£11.3m	£12.7m	£635	£726
3: Spreader calibration	6,819	13,933	£3.0m,	£7.6m	£530	£575
4: Manure N Supply	4,755	13,440	-£0.7m	-£2.0m	-£148	-£156
5: N Timing	7,156	17,328	£5.1m	£13.7m	£747	£820
6: Manure Timing	2,347	17,731	£0.6m	£4.4m	£245	£248
7: Clover	108,827	224,950	-£18.7m	-£40.6m	-£197	-£208
8: Grow low N crops	183,563	387,842	-£71.6m	-£146.7m	-£405	-£404
9: Livestock Breeding	121,961	512,230	-£33.4m	-£55.7m	-£117	-£118
10: Optimal Diet	18,482	50,588	-£1.5m	-£4.8m	-£82	-£98
11: Anaerobic Digestion	6,643	6,643	-£25.6m	-£25.6m	-£4,667	-£4,667
Total	**502,353**	**1,330,358**				

All the figures in Table 2 are for England only. It shows that only three MMs are estimated to provide more than 100k tpa CO_2e of abatement. The fertiliser planning and application MMs are not estimated to provide significant abatement. This is mostly due to the findings from the survey in AC0222 that there is already a high level of uptake.

Nutrient management MMs

This group of mitigation methods is listed below:

[2] Agriculture Industry GHG Action Plan, 2010. A framework to reduce emissions from agriculture in England by 3m tCO_2e per annum from a 2008 baseline by the third budget period, 2018-22

1. Use RB209, PLANET or similar tool to work out how much N to apply
2. Calibrate your fertiliser spreader every year
3. Take into full account the amount of N supplied by manure
4. Measure soil N supply before deciding how much N to apply
5. Use precision farming techniques
6. Avoid applying mineral N fertiliser before the crop starts growing in spring
7. Avoid applying slurry / manure before the crop starts growing in spring
8. Don't apply mineral N for at least 5 days after applying manure
9. Spread mineral N over 2 or 3 applications rather than just one application
10. Don't apply mineral N for at least 5 days after heavy rain

These MMs show relatively limited scope for GHG reductions from the results of AC0222. Therefore any plan to reduce GHGs using these would need to be low cost. Nutrient management provides multiple benefits in terms of diffuse pollution and can be cost beneficial to the farmer. Existing publicly-supported advice channels on nutrient management, such as England Catchment Sensitive Farming Delivery Initiative (ECSFDI), could incorporate the potential GHG advantages. More generally, there is widespread use of private consultants to manage nutrient application, although these have an inherent element of risk-aversion in terms of crop output.

Detailed comments are shown in Appendix 4, but in general, dairy and livestock farmers increasingly rely on contractors with precision farming equipment for mineral N and manure application. Where this is not the case, RB209 was considered too complex and 'rule of thumb' was used. In contrast, arable farmers felt RB209 was too general and used a more precise approach. All farmers took the trouble to include nutrient values in manures, but precision farming and soil mineral nitrogen measurement were seen as difficult to justify unless N status was uncertain. For the timing MMs (6 to 10), all farmers agreed with the concept in principle, but workload and timeliness took precedence. That is, in unpredictable weather, farmers would be interested in ensuring nutrients were available than strictly applying the rules and missing the opportunity to meet crop needs due to rainfall for example.

Clover

Clover has the third highest potential according to AC0222 and is cost beneficial to the farmer. The workshop feedback was positive with reasonable current uptake but potential for more as farmers could see the benefits. A key perceived barrier raised in the workshops is the availability of herbicides, whereas the other perceived issue, bloat, was seen as a minor concern.

"Most farmers are using it and many are thinking about using more, but it is difficult to find a spray to control weeds in clover. You can use spot treatment by quad bike or knapsack sprayer. A good way to introduce clover is to sow into one field and get the cows to graze it in flower then they spread the seeds without the need to cultivate"

– Dairy / Modern Family Business

"This is a more feasible option than some of the others in this area and it might be a good idea to grant aid it in the uplands. The problem is that most sprays for weeds in clover have been taken off the market"

– Livestock / Custodian

"This is an easy MM to implement, because most farmers already use at least some clover in their seed mixtures. The problems are the risk of bloat and the restricted range of herbicides to control docks"

– Livestock / Modern Family Business

This is an example of where perception lags behind reality, where barriers reflect the limitations of previous experience of clover that have now been overcome with new varieties. Advice and demonstration or monitor farms would be an effective method of improving knowledge and practice.

Low N crops

AC022 estimates this to have the second highest potential of the MMs evaluated. It is also estimated to be cost beneficial to the farmer, based on costings for triticale. There was widespread knowledge of triticale in the workshops, but the experience of success from the participants was mixed. Farmers were clear on the need for market development as it was perceived not to provide the cost benefits as modelled in AC0222. The potential is based on relatively limited evidence which needs validating to improve understanding of farmers and demand side.

This is again an easy MM to implement on the farm, since in the case of triticale it appears to be a direct substitute for wheat, based on the evidence available. However, the main barrier is a lack of market interest or channels. As with clover, the crop has been around for some time with limited uptake; however, it was suggested that if the market developed, commercial drivers would drive uptake.

"If triticale became an opportunity, crop assurance schemes and agronomists would be relied upon for guidance"

– Arable / Modern Family Business

Livestock breeding (use of sires with higher breeding potential)

This MM is estimated to have the highest GHG reduction potential of those evaluated in AC0222. Animal health was viewed as something worthwhile, since it provides financial returns as well as GHG reductions. Livestock farmers frequently bought breeding animals on price not quality – however, there is limited potential estimated in non-dairy livestock. The livestock sector did appear to be prepared to consider changes in breed in contrast to the dairy sector respondents who almost exclusively use Holstein genetics already and are focussed more on incremental livestock improvements.

Farmers have been encouraged for many years to improve breeding characteristics with mixed success. In the dairy sector, the main driver is economics, where yield has taken precedence for some time although in recent years, fertility, health and longevity are becoming more prevalent. The issue is more complex in the beef sector with returns significantly dependent on market prices on the day of sale as well as achieving target growth rate. In the workshops, producers felt that breeding was strongly influenced by costs and local custom (for breed and type). The inference is that it may require more than advice to change behaviour.

"As well as breeding for productivity and long life it is very important to breed for health. Animal disease is a very large waste – Tuberculosis is a factor that should be borne in mind when considering livestock MMs. "

– Livestock / Pragmatist

This quotation also highlights a conundrum in the livestock sector, where diseases such as Bovine Tuberculosis appear to be beyond farmer's control and limit their enthusiasm for wider health management actions. While this is particularly the case in the South West, where the dairy workshop was held, it highlights an important barrier which policymakers need to consider.

More generally, the issue in the livestock sector is a disconnect from market signals – linking returns to management decision – and a rather fatalistic attitude to returns, which limits their investment in genetics.

"Some farmers go on price, not quality when they use a bull and use left over beef heifers as suckler cows that produce low grade calves "

– Livestock / Pragmatist

In the same way as spending on health and other inputs, farmers are keen to minimise the risk of losing in gross margin terms, so they see the cost of good breeding policy as a barrier to uptake.

The following points also came out of the livestock workshop, initiated by a range of farmers and agreed by consensus:

- Some farmers may take up options for improved breeding but some are more influenced by price and do not look at breeding that closely.
- There is a need for knowledge transfer, training and support.
- The sheep sector seems to lag behind on breeding issues.
- Issues connected to optimum feeding times, nutrient content of feeds etc all become irrelevant if the health of the stock is poor.
- The barriers are that many farmers are part-time in this sector and they may not have the knowledge or time to consider breeding programmes
- There is a need to engage with "hobby" farmers.
- Farmers need to realise the benefits of Estimated Breeding Values (EBV)[3].

In addition, there are the MMs not included in AC0222:

Precision farming

Precision farming was not seen as widely relevant in any of the workshops or telephone interviews apart from land with variable soil type, where it was likely to be more cost effective.

"Precision farming is no help above other management techniques. Crop prices are too low to justify the cost"

– Arable / Pragmatist

"Precision farming techniques are mainly used by contractors that farmers employ, but they can't justify them on their own farms"

– Dairy / Modern Family Business

Livestock breeding (changing the breed of livestock)

This MM was not seen as necessary by dairy farmers who felt that they had all the relevant genetics available to achieve abatement through greater productivity, longevity and health in Holstein and Friesian-Holstein stock. No dairy farmers were

[3] EBVs predict the superiority (or inferiority) of the genes that an animal possesses for each measured trait. They are expressed in the same units as the recorded traits (e.g. kg for liveweight) and expressed relative to a common baseline for all animals in the same evaluation.

prepared to change breed, but would use existing genetics to select for required characteristics.

"This is already in place, cattle longevity is very important. Farm assurance schemes are harsh when milk price is reduced so much on cell count. Margins drive profit which drives input use"

– Dairy / Pragmatist

Beef and sheep farmers are represented by a much wider genetic base and were more prepared to change breed in response to market requirements for locally produced meat, for example. While the diversity of breeds used offers much higher scope for change than within the dairy sector, it also highlights a range of drivers, of which economic returns are but one. Cultural norms and a lack of clear market signals also make the drive for genetic improvement more difficult to secure.

Cover slurry tanks

This MM was aimed directly at dairy farmers, since slurry systems are less commonly used by beef producers, although it was discussed in both workshops. Neither group of farmers were convinced that it could contribute very much directly to abatement because covers are not sealed and would be reluctant to use it due to the cost involved and the risk of wind damage. This is a case where advice may produce little response and regulation may be necessary as in Denmark.

Use of growth promoters

This MM was aimed directly at beef producers and whilst most felt that it would provide an opportunity to increase profit if legalised, some said they would never use them because they did not think that was the way to produce food.

The use of growth hormones received a mixed response. It would largely depend upon whether the major retailers allowed it and on consumer response.

3.3 Potential uptake by farm type

Large farms in the dairy sector are estimated to have the greatest potential of all the farm type and size sub-sectors and the large farms in cereal, general cropping and mixed are estimated to provide around 55% of the reduction potential from less than 30% of the farms (AC0222). Overall, LFA and lowland cattle and sheep show the least potential. This is reflected in the views of the farmers where in the workshop; livestock farmers felt they used little nitrogen and limited cultivations, with resulting low levels of emissions per unit of production. The livestock group agreed that many of the MMs are currently being implemented regardless of farm size. However, a few places still do not have the slurry storage capacity needed (MM7) on cost grounds.

"Most of the mitigation methods are already in place as farmers do not want to waste anything; they are trying to make money"

– Livestock / Lifestyle Choice

"Many of the MMs do not apply to the livestock farming sector because of the limitations of where we farm"

– Livestock / Custodian

"The beef and sheep sector is already a low user of fertilisers and uses very little slurry"

– Livestock / Lifestyle Choice

Table 3 shows the variation in potential of the key MMs by sector and within this by farm size, based on industry statistics. It highlights the significance of large farms (excluding Cattle and Sheep farms) due to scale of operation and also the higher scope within the dairy sector in particular.

Table 3: MM potential by farm type and size (Defra AC0222)

Farm Type	Farm Size	Total Mitigation Potential (tCO_2e) Lower	Maximum
Dairy	Small	25,152	62,703
	Medium	30,263	96,311
	Large	113,757	333,103
Lowland	Small	10,479	44,714
	Medium	4,927	20,247
	Large	9,800	39,429
LFA	Small	9401	33,073
	Medium	10,273	25,964
	Large	13,092	44,932
Mixed	Small	15,524	45,189
	Medium	14,235	59,441
	Large	55,046	154,718
Cereal	Small	31,160	58,189
	Medium	30,600	56,531
	Large	68,325	124,511
General	Small	11,135	24,534
	Medium	8,546	19,235
	Large	48,646	106,339

3.4 Attitudes and behaviours

The analysis of the questionnaires shows that farmers feel that GHG issues are important, but that other matters such as getting on with their business are more so, particularly in challenged enterprises.

Whilst the livestock farmers were interested and happy to consider implementation of MMs, they were more affected by the practical constraints of their situation and immediate economic drivers, rather than achieving technical objectives as exemplified by the following quotes:

"Finishing targets are all very well, but whilst an animal may be ready for market on a target date at a target weight, if prices are low, stock are kept until prices are better"

– Livestock / Lifestyle Choice

"A lot of decisions are made for economic reasons and room for manoeuvre is tight with the narrow margins we farms operate on"

– Livestock / Custodian

"Market prices of fertilisers, stock and feeds and the weather are the main influences on practices adopted on the farms"

– Livestock / Custodian

These comments underline the generally modest returns that livestock farmers secure together a perceived lack of control over uncertain markets and extremes of weather in hill areas.

The following figures show the perception of GHGs by farmer segmentation type, farm type and farm size. Regardless of the characterisation, it is clear that in general, climate change is not at the top of the priority list. It is interesting to note the high proportion of challenged enterprises that see climate change as being not at all important, compared with the higher importance to custodians and lifestyle choice segments.

In terms of farm type, a relatively high proportion of arable farm delegates perceive GHG mitigation as very important. In terms of farm size, larger farms appear to recognise it as more important than others, although overall, the evidence is not conclusive. Whilst this indicates that GHG issues are not very important to farmers in general, most demonstrate a willingness to consider abatement actions provided profitability is not compromised.

Figure 3: Perceptions of GHG issues by farmer segmentation type

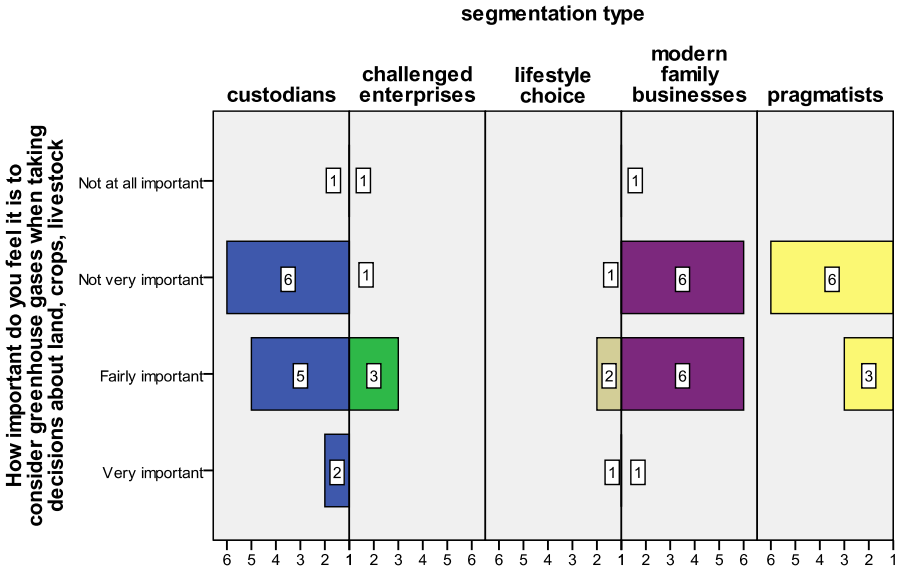


Figure 4: Perceptions of GHG issues by farm type

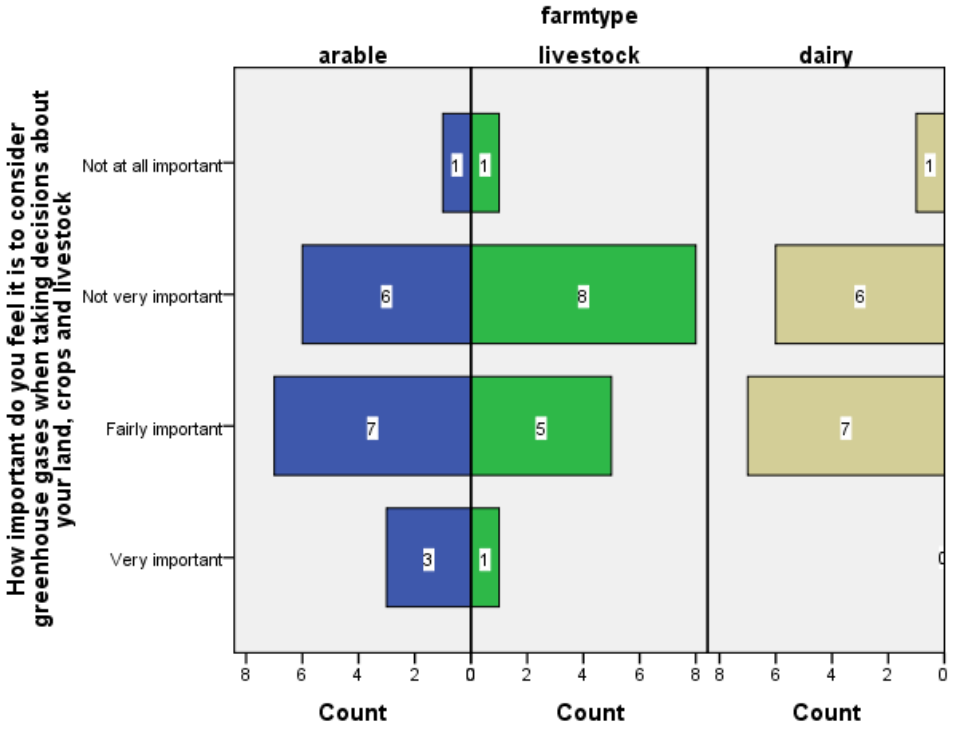


Figure 5: Perceptions of GHG issues by farm size

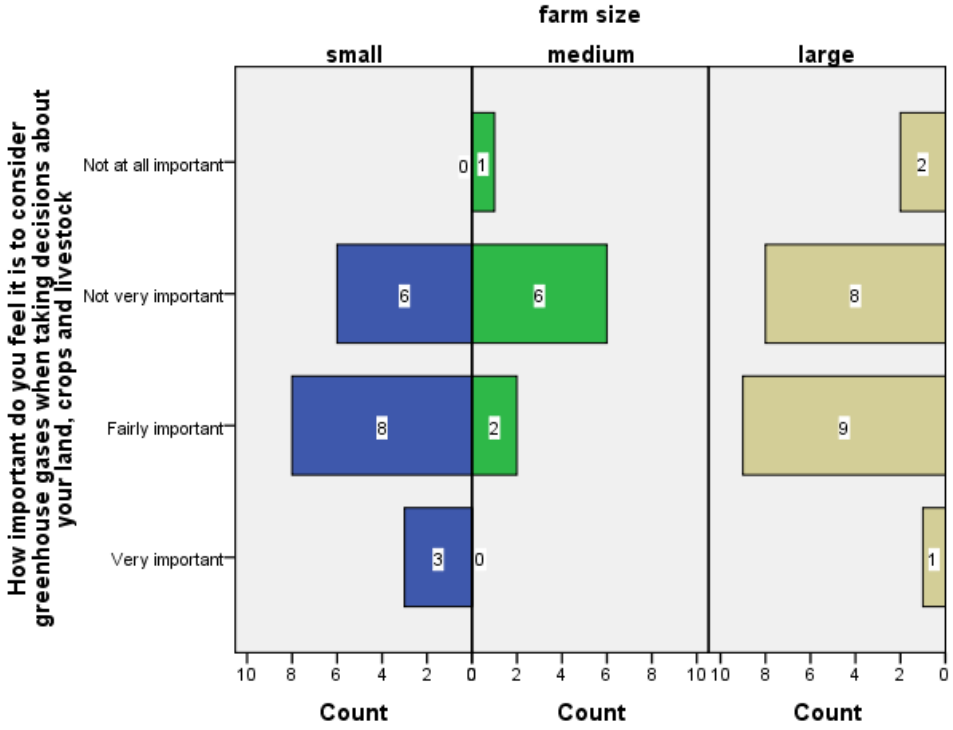
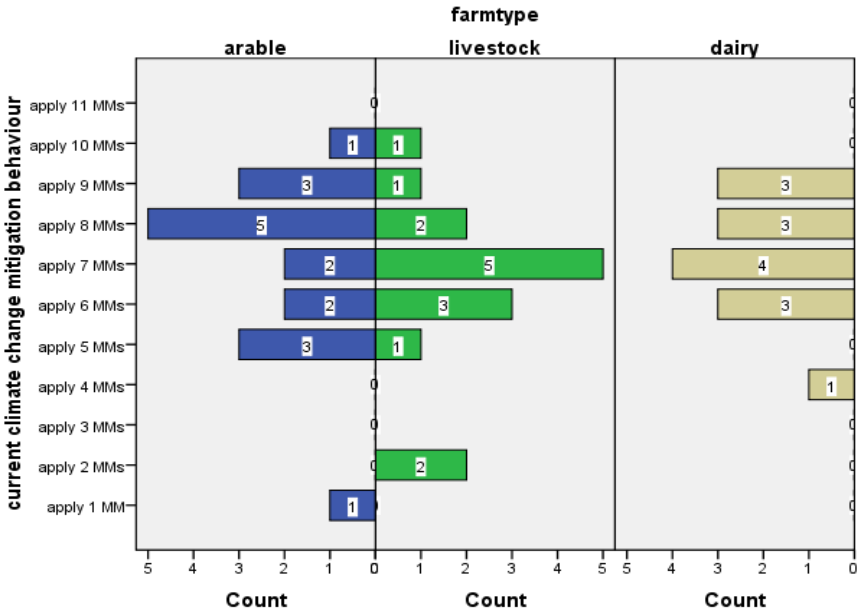


Figure 6 shows the extent of implementation of MMs by farm type. There is little difference between farm types, although it would appear that on average, arable farms tend to implement more MMs and livestock farms fewer.

Figure 6: Current GHG mitigation behaviour by farm type (MM1-11 – all farms)



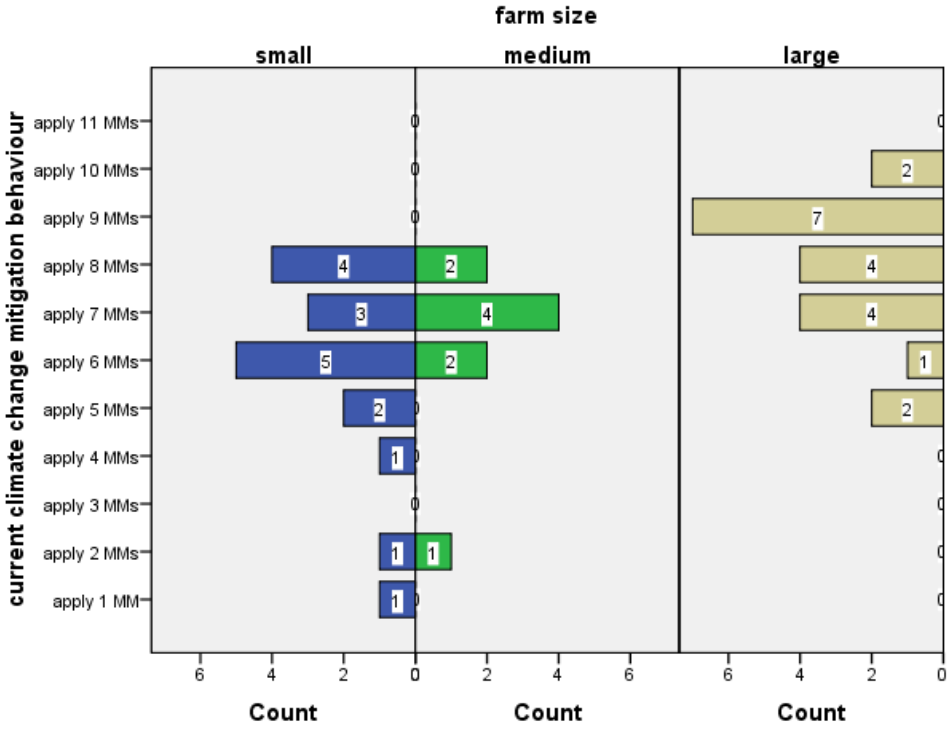
Clearly, farms of all types studied are already practising a range of MMs. When questioned in the workshops, the reason was not directly connected with GHGs but economics, such as the cost of mineral N fertilisers.

"We calibrate our spreader due to cost of fertiliser"

– Arable / Modern Family Business

Figure 7 suggests that larger farms tend to implement a greater number of MMs.

Figure 7: Current climate change mitigation behaviour by farm size (MM1-11)



In terms of farmer segmentation, it is interesting to note that from the limited sample in the workshops, uptake of MMs is high in challenged enterprises and lower in custodians (Figure 8) in spite of their level of perception of the importance of climate change. This may be explained by the fact that so many of the farmers were applying MMs for economic reasons and challenged enterprises are likely to reduce inputs to contain costs. For the MMs associated with dairy and livestock farms, custodians and pragmatists apply a greater number than other farmer segmentation types (figure 9).

Figure 8: Current GHG mitigation behaviour by farmer segmentation (MM1-11 - all farms)

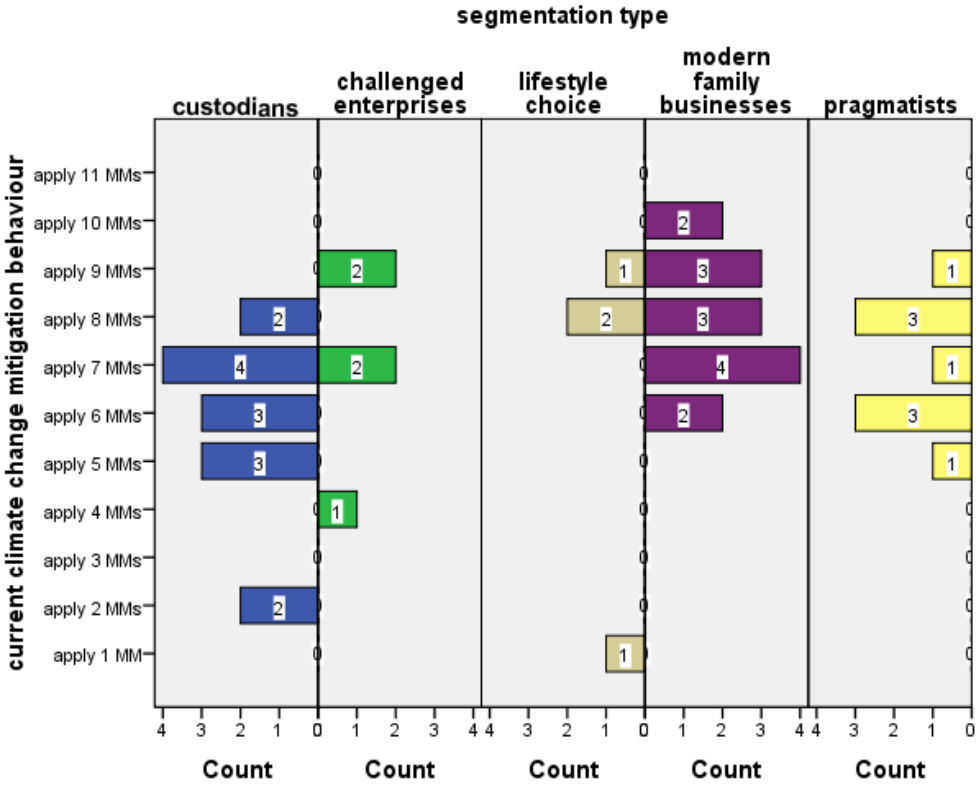
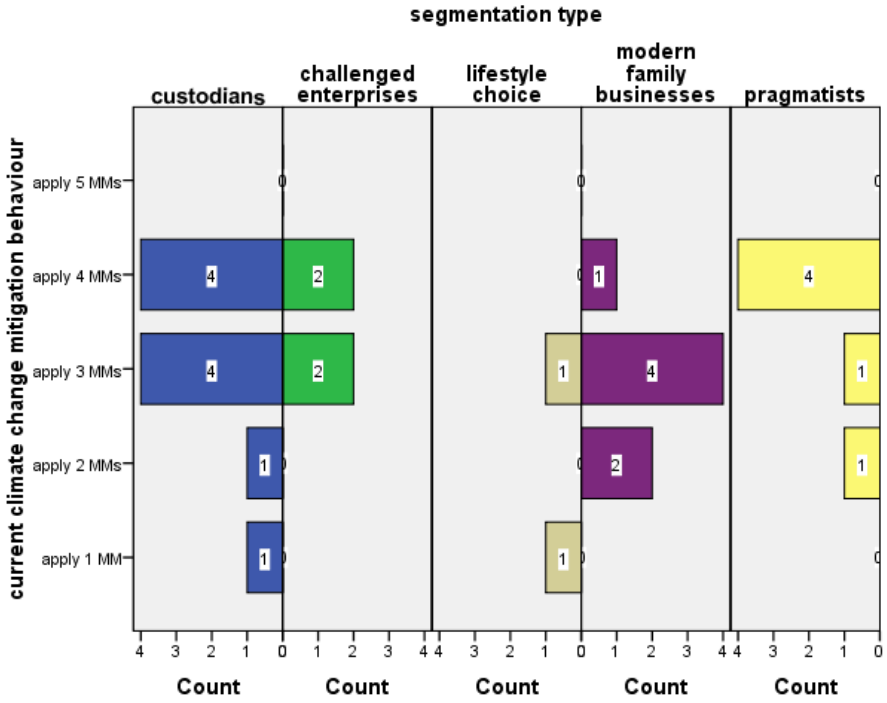


Figure 9: Current GHG mitigation behaviour by farmer segmentation (MM12-16 – dairy & livestock farms)



The analysis shows that whilst most farmers consider climate change to be fairly important or not very important, many of them are practising MMs across all farm types, sizes and segmentation type with relatively small differences between the categories in each analysis. The spread of the number of MMs implemented is large as indicated in Table 1. However, uptake is largely related to economic drivers and making the best use of inputs rather than concern to reduce GHG emissions. In addition, most livestock farmers (based on the sample) feel they have limited scope to implement MMs due to the nature of their farms.

This would indicate that in designing policy, it is important to target sector-specific MMs, emphasising the economic opportunity associated with reducing GHGs alongside wider promotion of BMP. In terms of approach, evidence from the farmer segmentation work should shape the emphasis on use of different communication channels.

3.5 Drivers for change

The question of drivers to the uptake of MMs was asked directly of each MM at each of the workshops and in the telephone interviews. There were a few common agreed drivers and they revolved around economics and best management practice.

Drivers, in order of priority, were:

1. **Economics**: *Would the MM save or cost money?* The MM should be at zero or negative cost if the farmer is to take it up without some form of support. If the business could benefit from an MM, it will be viewed positively by many farmers. This is so for all of the MMs related to nitrogen use, where recent practice has been to increase the accuracy of use of this increasingly expensive input. With the present level of knowledge, farmers are implementing MMs for economic reasons without necessarily considering GHG mitigation.

2. **Best management practice**: *Is the MM something the farmer should be doing anyway?* Many of the MMs presented to the farmers are in essence BMPs, both in terms of good agricultural practice and good business practice. Farmers are generally very concerned to maintain or improve the quality of their land and see it in their best interests to do so to achieve high output and to avoid penalties for poor husbandry.

3. **Markets**: *Can I sell or use the product?* Farmers produce for established markets and while they will respond to changes in market requirements, they are generally risk-averse. A good example is triticale, where farmers in the workshops would be prepared to grow it provided it had a market and it was competitive with alternatives such as wheat, but none would seek to develop a market (see next para.). While this applies to the feed grain market, it may find greatest opportunity in ethanol production, where norms are less well-established. Biofuel companies could play an important role here in specifying grain and facilitate market development on both economic and environmental grounds.

4. **Peer pressure / custom**: *Is anyone else (locally) doing it successfully?* Farming is a family business, often passed from one generation to the next and farmers are sensitive to tradition and reluctant to pioneer. Many of the responses in the workshops with regard to whether an MM would be taken up were positive if they saw that a neighbour was already successful using it. This driver cuts across the other three barriers and should be a key component of the strategy for promoting low-carbon farming

Often, there is a mix of drivers for uptake depending on whether an MM will save or incur cost, if it involves risk or not and if it represents a significant shift from established traditions and norms.

3.6 Barriers to change

A range of barriers was identified, which naturally fell into five types:

- Structural
- Financial
- Educational
- Management
- Administration

Structural barriers

Conflict with other policy or farming aims was highlighted in all three workshops where farmers did not want to be encouraged to do one thing under one policy and another for another policy. All farmers felt it was very important to ensure continuity of policy objectives.

"We don't want new schemes coming along that conflict with what we are already trying to do"

– Arable / Modern Family Business

Farmers in the livestock workshop were aware that many in that sector worked on their own or were part time and may be hard to reach adding to the challenge of effective dissemination of information.

The majority of farmers at all three workshops highlighted the high average age of farmers and their likely disinclination to become involved in new approaches. For some, if this meant farming more extensively, it may in fact be an attractive opportunity to work at a slower pace, but for others it may represent increased interference and uncertainty. Added to age is the issue of succession and the absence of a successor may deter implementation of MMs for those seeking to 'wind down' to retirement.

"Some people might be too old to bother with any of this, especially if they have no one to take over the farm when they retire"

– Livestock / Custodian

Security of tenure also limited some MMs, notably those linked to productivity, such as a long term commitment to use less fertiliser or to improve biodiversity, or those involving capital investment, for example slurry storage, all of which can affect tenancy agreements.

"Some Environmental Stewardship options last for a number of years and it is important for tenants to obtain their landlord's permission"

– Livestock / Modern Family Business

Opportunities to overcome structural barriers include:

- Addressing complexity: An example of complexity can be found in RB209, where dairy and livestock farmers in the workshops both asked for a simple version of the grassland section to be produced. By contrast, arable farmers said that RB209 was very general and they took a more detailed approach on a field by field basis because of the importance of accurate nitrogen application to their farming. The different perceptions relate to producing an even arable crop (particularly cereals) and the complexity of allowing for animal manures. In the case of nutrient use, a structured approach would be welcomed where farmers could choose the level of detail they felt applicable to their systems and take advice where their needs exceeded their knowledge.

  This issue also relates to the complexity of policy interventions; for example, a number of workshop delegates commented on the complexity of HLS in particular.

- Allowing for issues of tenure: For barriers associated with tenure, a break clause in any long term commitment may be necessary to encourage farmers and landlords to take up long term options that potentially affect the rental value of the farm.

- Effective communication: As farmers become older, they become resistant to change, particularly if they do not have a successor. However, while a commitment to implement a range of MMs may seem daunting, it may reduce the farm workload and fit well with this group's objectives. Provision of the right type of advice may be an effective way to overcome such barriers, for example, in FF0202 many farmers refer to trusted sources for advice rather than public sources.

Financial barriers

In all workshops, farmers emphasised the high cost associated with the technology to implement some of the MMs, for example precision farming and this was a significant disincentive. Similarly, MMs related to slurry storage, were perceived to be dependent on availability of finance, the value of the slurry stored and the payback period. With the present low profitability reported in both dairying and livestock workshops, concerns were expressed that all of these factors were a big disincentive.

In practice, many of the MMs are actually cost-negative, but an additional incentive may be required. For example, where slurry storage may be required to allow spring application, farmers in the livestock and dairy workshops were clear that financial support would greatly assist the implementation of this MM.

Educational barriers

The majority of farmers at all the workshops felt that there was a significant lack of knowledge, understanding, skills, training and support relating to GHGs, their relative importance and mitigation options. Lack of knowledge and understanding can mean that the more tangible cost of implementation is evident, but the benefits are not. One example is livestock breeding, where a relatively small cost increase can result in significant increases in income, provided correct management is applied.

Overcoming educational barriers is broadly linked to the provision of information and advice. It was clear from the responses in the workshops in FF0201 and the survey in AC0222 that farmers have limited knowledge of GHGs in relation to agriculture in general and the level of their own farm emissions. It is also clear that whilst farmers see GHGs as relatively important, they are secondary to viability and production.

Opportunities to overcome educational barriers include:

- Provision of general information on GHGs in agriculture: While this may hold some interest for farmers, they are more likely to respond to a more focused approach, linked to MMs relevant to them and with clear benefits in terms of savings likely or incentives for providing environmental services. This is already in place to some extent through Farming Futures.

- Advisory groups: Group activity such as that run by the Agriculture and Horticulture Development Board (AHDB) bodies, for example DairyCo and EBLEX, are able to target farmers in a single sector and use peer learning and group dynamics to encourage uptake.

- Engaging intermediaries: Providing information and training to advisors, consultants, contractors and ancillary trades may help engage farmers who do not normally take part in advice and demonstration activity due to time or attitudinal constraints. This was a conclusion in FF0202 and came out clearly in the livestock workshop in particular where it was pointed out that many small upland farmers are working at full capacity and unlikely to have the time to devote to behaviour change without positive outreach and technical assistance.

"The size of the farm is a barrier to implementing some of the measures - for small one man units it may be hard to implement"

– Livestock / Custodian

Management barriers

Management barriers refer to perceived impacts on the running of the farm on a day to day basis. All farmers at the workshops agreed that the most important factors in their management decisions are market prices of fertilisers, livestock and feeds and the weather, with no mention of GHGs or climate change. So in order to encourage uptake of MMs, the focus should be primarily on how they can address business issues and then on the consequential benefit of abatement.

Analysis of the workshop data indicates that many mitigation methods are already being implemented to a large extent and as a consequence all respondents state they will not change their current behaviour in regard to these MMs. This lack of scope was supported by comments during the workshops, where many dairy and livestock farmers in particular felt that they were implementing a number of methods to the fullest extent possible on their farm.

"Most of the MMs are already in place as farmers do not want to waste anything; they are trying to make money"

– Livestock / Lifestyle Choice

For those MMs in the 'Avoid excess N' group in particular (e.g. N timing), farmers gave this as the reason for being unwilling or unable to change and it was not that they were unreceptive.

One area that may provide further scope for implementation is on farms using contractors. In the livestock workshop and interviews, the majority felt that it would be necessary for any policy to engage with contractors who carry out a great deal of fertiliser spreading. At present, the focus of contractors is on the logistical demands of getting the job done in the shortest time possible. Taking account of mitigation requirements may impose additional management time on their schedules.

AC0222 listed barriers to uptake as follows:

- A high proportion of farmers who do not currently adopt the MMs stated that there was nothing that would encourage them to implement the methods with typically over two thirds unwilling or able to change practices
- Reasons varied with MM but typically involved the need for more local evidence that it was economic to adopt the practice.
- Smaller farmers often felt that they were not big enough to justify changing practice
- Cost of implementation was rarely mentioned, although having sufficient profit was a barrier. This compares well with the point above (Finance) in the response to the questionnaires in FF0201.

All of these points are consistent with quotes from the livestock workshop in FF0201, reflecting a need for knowledge and understanding about MMs. For example, while this not a lack of evidence on the economic case for including clover in grassland, it has been communicated largely to farmers with a specific interest, in particular the organic sector, while others have not been actively engaged. In itself, the association of clover with organic systems can be seen by non-organic farmers as driven by regulation (fertilisers are prohibited) rather than economics *per se*.

Low farm incomes were highlighted by all farmers as a barrier, particularly in the livestock sector. These could be compounded by issues of motivation: age, succession, investment, timescale, personal energy. In the quantitative analysis of the workshop responses, cost was found to be the main determinant of potential behavioural change. When asked specifically whether cost was an issue, farmers said that it was, although this was a barrier that was not mentioned without prompting. This correlates well with AC0222.

The majority of arable farmers saw staff turnover as a barrier to implementing MMs more widely, because they would often be the ones to implement the MMs at field level on a day to day basis. For livestock farmers in particular and dairy farmers to an extent, the impact of animal disease was noted, where BMP on optimum feeding times and nutrient content of feeds become irrelevant stock health is poor.

Finally, the role played by habit in management decisions was highlighted by livestock and diary farmers where, for example choice of breeding livestock is often seen as a cost rather than an investment. This seems to be particularly true in the sheep sector.

"A lot of breeding rams are still bought on cost not quality"

– Livestock Farmer.

In conclusion, it is imperative that MMs are seen as relevant to the mainstream, associated with progressive and successful farmers and cost-effective to all.

Opportunities for overcoming management barriers include:

- Peer pressure: Following the example of other farmers was found to be the main determinant of the potential behavioural changes and other determinants were information, advice and training
- Education and awareness: Clarifying potential implementation of an MM would help farmers see how far they can go with uptake of MMs.

- Provision of information and advice: Focused support through paper, electronic and advisory means that support local demonstration or monitor farms would enable farmers to make informed decisions on the viability of the implementation of MMs in their businesses.

- Promoting MMs as best practice: Presenting MMs in the context of BMPs would help farmers to see their relevance to their management practices.

Administration barriers

With regard to the Code of Good Agricultural Practice (COGAP) MMs, representatives at the Industry Day felt that the style of communication with farmers was very important in minimising barriers. They felt that the wording of several MMs gave negative impressions, for example, by using the words 'don't' and 'avoid', whereas positive language may indeed overcome barriers. Few farmers would have time or inclination to look at GHG issues in detail and for example highlighting improved profitability of better N planning and application with consequential benefits of GHG abatement amongst others (e.g. mitigation of diffuse pollution, reduced risk to biodiversity) may be more appealing to farmers. The phrasing of the MMs did indeed cause some confusion in the livestock workshop.

As above in Structural barriers, complexity of regulations was a concern for dairy and particularly livestock farmers who felt it prevented effective implementation and were afraid of making mistakes that result in severe penalties. All farmers were concerned that policy should be consistent in its objectives and not subject to frequent changes. Paperwork was seen as a significant barrier for a wide range and type of policies.

"We need a major overhaul and simplification of policies"

– Livestock / Modern Family Business

Industry representatives thought that barriers would be created by introducing regulatory policy because farmers would feel they were being compelled to do things rather than having the opportunity to innovate and use their knowledge of their farms to make their own judgements. In the workshops, farmers felt they could implement MMs more effectively given the opportunity through policy targeted at advice informing them they could increase efficiency/profit. In delivering advice, there are a number of sources and agencies currently involved and the majority of delegates believed that improved co-ordination and communication to make the most of each farm visit would add greatly to uptake.

This was the subject of FF0202 which highlighted many key points in this respect including:

- the existence of a network of advisory services providing flexibility.

- there is a large proportion of land and soil management and habitat/biodiversity advice. This could be used in connection with GHG MMs if they were linked to existing schemes like CSF or Environmental Stewardship.

- farmers prefer a trusted source of advice

- whilst farmers may be unwilling to pay for advice, they are generally receptive and

- advice covers literature, web based, group and one to one approaches

The network of advisers would be easy to engage with through existing schemes such as CSF if further training were provided for advisers who may already be a trusted source for many farmers.

This relates well to the responses in the workshops and telephone interviews where many farmers said they relied on their advisor to assist with a range of management decisions covered by the MMs.

Opportunities for overcoming administration barriers include:

- A positive message: Keep language positive and emphasise business benefits more than GHGs.

- Avoid complexity of administrative systems: Make it easy to apply for schemes. This may be difficult where a number of options are possible such as the Higher Level Scheme of Environmental Stewardship, but the application process has created negative impressions due to the cost of application and uncertainty of acceptance. Farmers in the workshops were aware that some have spent over £1,000 only to have their application declined.

- Limit reliance on regulation: Regulation may be less costly to implement from a policy-makers perspective, but relies on a degree of 'one size fits all' and can limit innovation. Generally, farmers prefer to be given the opportunity to address a particular issue on their farm in the most appropriate and cost-effective way. Comments in the workshops suggest that an economic or voluntary policy that provided a framework of required benefits where farmers could apply them to suit the characteristics of their own farms would be likely to achieve a high level of engagement. This may appeal to a wide range of segmentation types, but perhaps more so to Custodians.

- Facilitation: Advice linked to policy is an important factor in delivering uptake volume but can also be important in terms of the 'quality' of action. There is a broad range of advisory sources available, through private consultants, the trade and professionals (e.g. vets, valuers) as well as public programmes such as ECSFDI and these should be harnessed where possible.,.

The barriers listed at Table 5 are a summary of the previous text taken from those reported in the farmer workshops. The size of the barrier indicates the perception by farmers and solutions came out of discussion in the farmer workshops.

As an example, formulation of policy was clearly highlighted as both a policy and administration barrier in the workshops. In terms of the solution, this was seen as something for government to address. There are two forms of barrier associated with policy, the first being how complicated it is to understand and the second being how difficult it is to demonstrate that it is being followed.

Table 5: Summary of barriers and means of overcoming them

Barrier	Size	Solution (from workshop discussions)	Est. cost
Policy complexity, language and style	✓✓✓	Action required by Defra policy makers to formulate joined up policy, easy to join schemes e.g. ES	✓
Timescale for farmer uptake	✓✓✓	Build in time for farmer engagement	✓✓
Small farms	✓✓✓	Make additional allowances for positive outreach and technical support for advisory schemes	✓
Tenure	✓✓	Build in cancellation of long term support agreements	✓
Demographics, age, succession	✓✓	Design of policy to accommodate these issues e.g. young farmers may have limited finances; older farmers may be engaged by opportunities to reduce workload.	✓
Finance	✓✓✓	Where there is a net cost MMs or an upfront investment, small grants can offer a good incentive for farmers to engage and act. ECSFDI represents a good example.	✓✓✓
Knowledge of both economic and environmental impacts and opportunities	✓✓✓	There is a strong case for developing farmer knowledge in order to provide a motivation for action. Evidence highlights the importance of demonstration and peer influence in changing behaviours.	✓
Advice	✓✓✓	Co-ordinated initiatives involving a mix of media e.g. web-based, press, to one, group and demonstration and monitor farms to inform and influence. It is also important to build on existing advisory channels (consultants, trade, public etc.) and the need to overcome attitudinal barriers using peer influence, local champions etc.	✓ to ✓✓✓
Lack of engagement of contractors, trade, consultants etc.	✓✓✓	This is both a barrier and an opportunity as they represent an existing and trusted communication channel, especially for hard to reach farmers.	✓
Stock health policy	✓✓	Stock health policy needs to be presented as an economic issue rather than a bureaucratic process, relating to animal identification, movements and testing.	✓✓✓

Key: Low cost: ✓ e.g. Defra own staff, production of leaflets
Medium cost ✓✓ e.g. staff costs to deliver scheme through compliance visits
High cost ✓✓✓ e.g. financial support for MMs and one to one advice with reports and follow up

Whilst many of the MMs are currently widely implemented, evidence from the workshops and follow-up telephone survey highlights interesting differences between the segments in attitudes to further uptake. In contrast, improved breeding techniques were well supported by livestock farmers but generally not implemented. Average scores often hide a balance of pro and anti sentiment. This is reflected in Figs 6 – 9 where there are large ranges within sectors/types/segments.

Table 6 provides a summary of the level of support or rejection by farmers at the workshops.

Table 6 Summary of level of support or rejection of MMs by farmers:

Mitigation method	Overall	Farm type			Farm size			Segmentation				
		Arable	Dairy	Livestock	Small	Med	Large	C	LC	P	MFB	CE
Use RB209, PLANET or similar to work out N to apply	✓✓	✓✓✓	×	××	×	×	✓✓	××	✓	×	✓✓	×
Calibrate your fertiliser spreader every year	✓✓✓	✓✓✓	✓✓	✓✓	✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓
Take into full account the amount of N supplied by manure	✓✓✓	✓✓✓	✓✓✓	✓✓	✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓
Measure soil N supply before deciding how much N to apply	×	✓	××	××	×	××	×	××	×	✓	✓	×××
Use precision farming techniques	×	×	××	××	××	××	✓	××	××	×	✓	✓
Avoid applying mineral N fertiliser before the crop starts growing in spring	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Avoid applying slurry / manure before the crop starts growing in spring	✓✓✓	✓✓	✓✓✓	✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Don't apply mineral N for at least 5 days after applying manure	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓	✓✓✓
Spread the application of mineral N over 2or 3 applications rather than just one application	✓✓✓	✓✓✓	✓✓	✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓	✓✓
Don't apply mineral N for at least 5 days after heavy rain	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓✓	✓✓✓	✓✓	✓✓
Grow triticale	××	×××	××	×××	××	××	××	×××	×××	××	××	×××
Put your manure into an anaerobic digester either on farm or somewhere else	×××	×××	×××	×××	×××	×××	×××	×××	×××	×××	×××	×××
Determine exact nutrition requirements of the livestock from the desired level of production	✓✓	N/A	✓✓	×	✓	✓	✓✓	✓	✓	✓✓	✓✓	✓
Introduce clover – white for longer term leys, red for short term leys	✓✓✓	N/A	✓✓✓	✓✓✓	✓✓	✓✓	✓✓	✓✓✓	✓	✓✓✓	✓✓	✓✓✓
Dairy - Seek high Profitable Lifetime Index (PLI) of livestock	✓✓✓	N/A	✓✓✓	N/A	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Beef - Seek high Estimated Breeding Value (EBV) of livestock	✓✓✓	N/A	N/A	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Sheep – Seek to improve optimum productivity	✓✓✓	N/A	N/A	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Covering slurry tanks to reduce ammonia and secondary emissions	×××	N/A	×××	×××	×××	×××	×××	×××	×××	×××	×××	×××
Growth promoters (Ionophores) e.g. Monensin	××	N/A	N/A	××	××	××	××	××	×××	××	××	××

Some support ✓; good support ✓✓; strong support ✓✓✓; light rejection ×; moderate rejection ××; strong rejection ×××

C = Custodians, LC = Lifestyle choice, P = Pragmatists, MFB = Modern family business, CE = Challenged enterprises

4. A segmentation approach

4.1 Building on motivations and overcoming barriers

A key message from the analysis on farmer motivation in this policy area is that while economics is the main driver, farmers see the uptake of best management practice as an important credibility issue but are also reluctant to move away from established practice in some cases. This varied across sectors with a greater reliance on established practice and norms on livestock units; this is most likely related to the fact that economic signals are buffered by a relatively long supply chain and there is greater reliance on farm subsidies.

There were no clear differences between behavioural types although the stronger business motives of Modern Family Businesses and Pragmatists, for example, could be important in terms of uptake. The use of a wide range of policy levers (regulatory, voluntary and economic) increases the likelihood of engaging a broad spectrum of behavioural types in order to:

- build awareness of best management practice
- promote and incentivise positive actions and deter negative practices
- build on peer influence through working with 'groups' e.g. ECSFDI
- support existing and foster new desirable approaches or 'norms'

While it is important to build on these positive attitudes where they exist, there is a generic problem in terms of lack of knowledge of GHGs in agriculture and the role farmers can play in mitigation. It was also clear that farmers are willing to take up abatement provided it does not compromise profitability or if they are compensated for any losses. This appeared to apply to cost-negative MMs as well as those requiring investment and the real barrier may be perceived return from change in the absence of adequate knowledge.

There was also evidence of resistance to undertaking a public good role in view of commercial pressures and the perceived burden of government regulation etc; this barrier may be difficult to overcome and it may be more constructive to promote best management practices and other changes which have financial benefits under an efficiency or competitiveness banner rather that saving the planet. There is an opportunity to deliver a win-win proposition.

4.2 Policy tools to secure GHG mitigation by sector / segment

To this point we have presented estimates of the mitigation potential of the MMs and how these translate to farm types, sizes and segments. Their perception by farmers from the workshops has also been briefly summarised.

Farmers prefer to have some form of input into what is done on their farms and see regulation as a burden, but would like to see the chance to exercise innovation through voluntary and incentive-led initiatives in order to utilise their local knowledge to achieve maximum business and environmental benefits. Even where some MMs are cost negative, perception can be a barrier and information campaigns are needed through conventional and new channels to change attitudes.

Table 6 does not provide conclusive evidence about how policy can be differentiated between sectors/types or segments due to the variation within any one group (Figs. 6

– 9). However, policies that are broadly-based and sensitive to a range of situations would promote wider uptake.

Costs could be shared with other policy where multi-objective farm visits were made by co-ordinating the various schemes. This came out strongly in the farmer workshops where they noted the multiplicity of visits they receive for various compliance reasons. Clearly, this would need to design out the risk of overlapping advice and the preference of some farmers to use trade sources rather than consultants. The relevance of existing programmes to individual MMs is summarised in Table 7.

Table 7: Options to deliver MMs through existing programmes

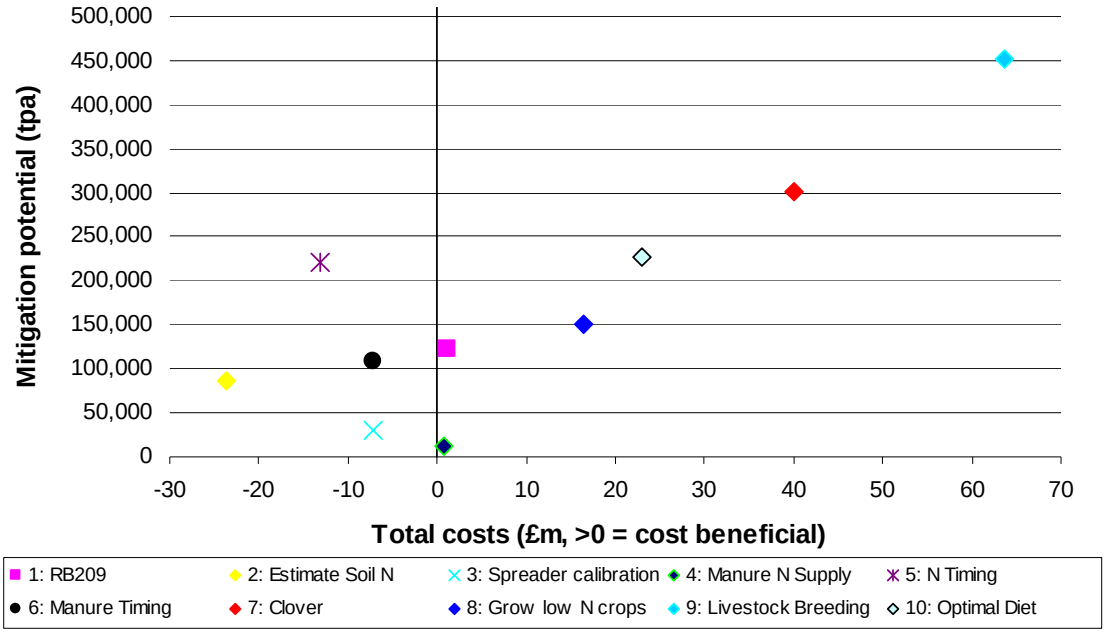
Mitigation method	Existing programmes
Nutrient management	NVZ, Cross Compliance, private advice and RDPE Axis 1 for cost beneficial MMs.
Clover	Since it is estimated to be cost beneficial, advice could be delivered via private consultancy as well as through RDPE Axis 1.
Low N crops	Could be delivered through Axis 1 on the basis of environmental benefit and competitiveness for the livestock sector or biofuels. Could be part of an advice/training related scheme but needs more evidence – through additional research or perhaps monitor/demonstration farms.
Livestock breeding	Animal health related improvements, given their cost beneficial impact, could be delivered through private advice channels as well as under RDPE Axis 1. Monitor/demonstration farms also a possibility

4.3 A costed plan for achieving GHG reduction

This section takes information from AC0222 showing an estimate of a lower and maximum increase in uptake and the resulting GHG reductions. The total cost of implementing the MM and the cost per tonne of CO_2e reduced are also included (where a negative cost means the farmer is estimated to make a profit from implementing the MM).

These figures are represented graphically in Figure 10. The x-axis shows the cost of the maximum implementation of the MM to farms (with the negative values in Figure 10 to the right in the chart) and the y-axis the aggregate emissions reductions. Most of the MMs are clustered around the origin showing small estimated emissions savings with relatively low financial costs or benefits. The 'best' options (encompassing large scale emissions reductions that are financially beneficial to the industry) would be in the top right of the graph.

Figure 10: MM potential and aggregate costs of implementation



It is clear from Figure 10 which of the MMs provides most potential to reduce GHGs. However, all MMs are not equal in terms of practicality and acceptability and the way in which they are perceived by the farming community. The MM potential can be delivered/targeted through different channels, some of which are already in existence but do not explicitly focus on GHGs.

Costed steps to increase uptake

To provide an initial estimate of costs of a plan to increase uptake, the results from the survey on uptake in AC0222 have been used to provide an estimate of the number of farms that have the potential to implement the MM or to do more of it. For each MM, the survey in AC0222 asked farmers whether they implemented the MM "always", "most of the time", "some of the time", "rarely", or "never". AC0222 weighted these responses e.g. "most of the time" was assumed to mean two thirds, and estimated the degree to which uptake could increase.

For dairy and livestock farmers, responses from the workshop indicate that the nutrient management MMs may not seem worthwhile in a grassland system. The lack of a market is a barrier for low N crops. For livestock breeding, cost is seen as a barrier to some. For ration formulation, most dairy farmers are required to implement this for farm assurance purposes, but livestock farmers tend to use experience.

The GHG plan costing uses the mitigation potentials from AC0222 and accepts the priority sectors as being the large dairy, cereal, general cropping and mixed farms. Table 8 shows the split between these farm types in England from FBS 2008.

Table 8: Number of large farms by selected farm type

Farm type	FBS 2008/09 large and very large farms
Cereals	2,349
General cropping	2,019
Dairy	4,559
Mixed	1,565

AC0222 suggests that these 10,492 farms can provide 54% of the mitigation potential identified. Much of the potential is locked within those farms that implement the MMs less than "always". The results of applying the proportions of large farms from the survey that replied "rarely" or "never" are shown in Table 9

Table 9: Estimated number of large farms that "never" or "rarely" implement

	Cereal	General	Dairy	Mixed
Use RB209	329	382	2,913	830
Estimate soil N	280	119	1,277	476
Spreader calibration	-	119	1,090	231
Manure N supply	141	-	228	146
N-Timing	19	11	29	36
Manure timing	611	420	1,185	383
Clover	-	-	1,087	551
Low N crops	2,253	2,019	4,194	1,514
Livestock breeding	-	-	1,368	823
Optimal diet	-	-	456	231

Cost of delivery through farm advice and training

Many of the conclusions in Defra project FF0202 (Agriculture advisory services analysis) relate to the needs and potential for the delivery of a plan to reduce agriculture GHGs. A degree of scepticism from the agriculture community has been expressed in FF0202, AC0222 as well as this project about climate change, the science and the effectiveness of some MMs. However, a number of MMs are estimated to reduce costs when implemented and further demonstration could be warranted as farmers are likely to be receptive to such low carbon advice. According to FF0202 advice is sought to improve profitability, achieve compliance and access grants. Environmental outcomes are of secondary concern to the farmer, although it is in itself important.

The FF0202 report included an analysis of the types of advice given, but this categorisation did not differentiate GHG advice and also suggests that most advice services would be in a position to include low carbon advice. As it stands, there could be a gap in carbon advice relating to livestock health and diet, but nutrient management measures are well provided for.

Clearly, since there are currently no formal advisory routes that include GHGs, there is a need to include them and it would fit well with other approaches in diffuse pollution, for example, where the MMs are very similar and there are a lot of synergies. One of the outcomes of the report which was backed up at the Industry day was the need to include ancillary trades to broaden the range of farmers reached. In addition to information, farmers were keen to see local evidence that the advice worked.

Farm advice can vary between schemes. ADAS is involved in providing advice under a number of different umbrellas including those public funded such as Catchment Sensitive Farming and the ELS Training and Information Programme (ETIP). There are also commercial and consultancy services available that involve far more detailed calculations, broader advice and input. The cost of a farm visit and report under ETIP might be around £650 but there is no follow up included to see if the training has been

implemented. For the more involved private consultancy solution, the cost varies with farm size but for a larger farm the cost may be £1,250 spread over two years (pers. comm. Steve Ford, ADAS).

The Farm Advice, Training & Information (FATI) Framework incorporates four themes, one of which is climate change. A Carbon Advisory Service provided through such a framework could incorporate most of the MMs in this project to a large degree. The template for such a scheme would need to include the messages in different forms which could include:

- Initial visit outlining MMs and potential on the farm including the financial benefits
- Provide the farm with technical updates that reflect the time of year that the farmer could use the information
- A website for reference and news, CDs, web based seminars
- A follow up visit to allow two way learning – to reinforce the benefits of the MMs and to gauge the level of implementation on the farm.

Such a scheme would likely cost somewhere between the ETIP and the private consultancy cost outlined above at around £1,500 per farm. Delivering such a programme to, say, 5,000 farms over 2 years would cost £7.5m. This would be in addition to any central costs, which would depend on whether the programme employed regional officers along the lines of CSF.

As a comparison, CSF in its first two years delivered advice to over 6,000 farmers (4,700 face to face and 500 group events). Excluding capital grants, the cost of CSF is £8m per annum, but this includes the cost of the CSF Officers and central support teams and costs at Natural England (NE) and the Environment Agency (EA). Taking such additional costs into account, a scheme to reduce agriculture emissions could cost of the order of £6m per annum (half of the £7.5m per year plus around 50% "on costs" which include CSF type NE and EA operations)

Cost effectiveness of farm advice

The non-traded cost of carbon in 2020 is £60/tonne (DECC 2009). For a Carbon Advisory Service to be cost effective would need to achieve mitigation of around 100,000 tonnes (£6m divided by £60/tonne). As mentioned above, the priority large farms account for 55% of the estimated abatement potential. Since the costs suggested above account for around half of the large farms (c 5,000), this equates to a range of 165k to 470k tCO_2e[4] pa of potential mitigation. So the cost effective target would need to achieve 60% of the lower estimated potential or just over 20% of the maximum. There are other MMs that could be expected to be included within a scheme, making a target more achievable.

The above simple assessment of cost effectiveness does not account for the improvement to farm finances that might be expected with the implementation of the more cost effective MMs. Looking at the cost effectiveness of the MMs per tonne of CO_2e in Table 2 for all MMs excluding AD (which is a highly capital intensive MM applied to only 900 farms), the weighted cost effectiveness per tCO_2e is around £-150 (a net benefit to the farmer of £150 for each tonne of CO_2e mitigated) suggesting a

[4] Mitigation potential (lower and maximum) multiplied by % of priority farms multiplied by % of farms receiving advice: 600,000 tCO2e * 0.55 * 0.5 = 165,000 & 1,710,000 * 0.55 * 0.5 = 470,000

potential net gain to the farmers in the scheme of around £15 m if a target of 100,000 tonnes is reached.

Further cost effective means could be employed by developing a system of multi-objective visits to complement other policy. This came out strongly in the farmer workshops where they noted the multiplicity of visits they receive for various compliance reasons, but clearly, this would need to design out the risk of overlapping advice and the preference of some farmers to use trade sources rather than consultants.

Potential roles for demonstration/monitor farms

The monitor farm model was developed in New Zealand and has been in operation in Scotland since 2003. They are designed to improve the performance and profitability of a commercial farm, typical of the local area over a defined period. An ADAS report on the effectiveness of the Scottish monitor farms (An Investigation into the Role and Effectiveness of Scottish Monitor Farms, Scottish Government, August 2008) estimated a benefit: cost ratio of 6.5:1 and this was believed to be an underestimate, since it was not possible to estimate the value of some of the improvements. The cost of the programme was estimated at approximately £18k per monitor farm per annum. It was noted that synergies of the monitor farm programme with other initiatives could be achieved through a co-ordinated presence on the internet coupled with a strategic approach to planning publicly funded advisory programmes through a regional forum of agencies. The MMs in this project could easily be included in such an initiative that would encompass other policy objectives in for example CSF and Environmental Stewardship

There have been two recent monitor farm projects started through the Rural Development Programme (Axis 1) in the North East and North West. The North West scheme involves 5 livestock farms (3 dairy and 2 beef and sheep) and began in early 2009 whereas the North East project began earlier this year and was to involve one livestock farm. Funding for the latter from RDPE was £195k and the project was expected to last 4-5 years. Taking the estimated cost of monitor farms from the Scottish example suggests that a monitor farm would need to deliver 300 tCO_2e per annum (from the farm itself as well as all those participating in the associated business group) to provide cost effective abatement (again excluding the business benefits derived that accrue to scheme participants).

Variations on the monitor farm model include public/private demonstration farm networks, for example, LEAF. The limitation of these is that they are often hosted by pioneers for environmentally-sensitive farming and as such not seen to represent the average commercial farm. They provide a valuable resource for the informed and willing minority rather than mainstream industry.

Hard to reach farmers

By definition, it seems unlikely that the participants within the workshops represent those farmers that might be classed as “hard to reach” in terms of the provision of advice and training. An ADAS project for Defra, Evaluation of the Forward Farming Pilot Demonstration Farm Project (March 2004), considered as a group those who did not have a history of attending demonstration events. The project constructed an information map for those who attended events and those who did not that showed how they communicate and participate within a range of information channels. The map for non-attendees showed a similar range of communication partners and participation routes, but that there was greater reliance from this group on the farming press and trade representatives.

This illustrates the need for a GHG reduction plan that includes a wide range of communication and participation routes to maximise the potential for MM uptake.

The 'hard to reach' farmers are categorised as such because they do not respond to conventional outreach programmes, but in a policy that took into account the influence of the trade and contractors, this omission may be addressed. Farmers at the livestock workshop in particular noted the likelihood that lone farmers in particular may be included in this group. They are still in contact with ancillary trades as a matter of routine and this may be an effective way to communicate with them

5. Conclusions and recommendations

There is a potential for substantial abatement from the MMs included in the project in spite of the fact that some are already implemented. In this concluding section we consider the key findings in terms of which methods to promote, targeted to which segments and using which policy tools.

5.1 Mitigation methods

Priority MMs

Whilst a broad approach to MMs will be needed to increase implementation, there were three MMs with significant potential:

Livestock breeding (MM 15): This is estimated to have the highest GHG reduction potential of the MMs evaluated in AC0222. The main opportunities are in the grazing livestock sector. Despite this, the livestock sector is resistant to changes in breed, in contrast to the dairy sector where it is recognised as a strong economic driver. Farmers have been encouraged for many years to improve breeding characteristics with mixed success and in practice there are multiple barriers including the long supply chain which buffers breeders from market demands and a reliance on subsidies. Advice should be targeted to those willing to change behaviour with a wider awareness campaign in association with the supply chain.

Low-N crops (MM 11): The AC022 estimates for this cover only triticale but with some limiting assumptions on its potential scope, it is still estimated to be able to reduce GHGs by as much as 150,000 tCO_2e pa. They can also be cost beneficial to the farmer, for example in the case of triticale, but the crop is not widely grown and markets not well developed. As such, existing evidence needs to be collated and validated to improve the awareness of farmers and help develop the demand side.

Clover (MM 14): This method has the second highest potential according to AC0222 and is very cost beneficial to the farmer. Issues of weed control and nutrition (bloat) are perceived barriers but a minority of farmers have used high-clover systems extensively for many years, notably in the organic sector, and a blueprint for managing the crop should be available.

Other opportunities

Nutrient management MMs show relatively limited scope for GHG reductions from the results of AC0222. However, they are widely applicable and can make a contribution and can be cost beneficial to the farmer. The combination of low marginal gain and the need to engage many farmers indicate that a low cost approach is appropriate, focusing on awareness. Nutrient management provides multiple benefits, including reducing diffuse pollution and it would be cost-effective to using existing communication channels where possible.

Specific conclusions and actions are required by MM group (Appendix 2) as follows:

Avoid Excess N (MMs 1 to 5): MMs 1 to 3 are widely taken up and in arable farming, but for grassland farmers a simplified version of RB209 is needed. MMs 4 and 5 have strong commercial drivers and no action is recommended

N timing MMs (MMs 6 to 10): Farmers perceive they are implementing these to a high degree already and any action should rely on evidence that this is not the case in specific circumstances. Further knowledge and understanding is required along with economic justification to encourage further uptake.

Low-N crops (MM 11): Need to collate and present the evidence for uptake of new crops as there is substantial scepticism among farmers

Anaerobic Digestion (MM 12): This is perceived as having overbearing finance requirements beyond the reach of most farmers and substantial grant aid is required to increase uptake. An appropriate scale of enterprise for this technology is key and any promotion should be targeted accordingly.

Livestock rationing (MM 13): This has a strong commercial driver in terms of increasing production and is a requirement of some farm assurance schemes; no action is recommended.

Slurry tank covers (MM 16): These were not perceived as attractive to the dairy or livestock farmers and a targeted economic case needs to be made to promote uptake; no action is recommended.

Growth promoters (MM 17): would need to have their prohibition lifted to enable them to be used, but beyond that, they would need to have market acceptance and many livestock farmers doubted that would be forthcoming at present.

5.2 Segmentation

Analysis of responses shows that there is a wide range of implementation within farmer segmentation types, but that overall, no one segment stands out as implementing more or less MMs to any significant extent. While this is not helpful to policy makers, it is consistent with the high degree of heterogeneity within the industry, for example, there are many progressive small farms and financial aptitude is not strongly associated with age.

In principle the behavioural typology should identify some association with attitudes to change generally and GHG mitigation in particular and the fact that this was not observed may reflect the scale of the sample. Some broad associations suggest that:

- Challenged Enterprises may be the least likely to implement MMs, since they are already finding their situation difficult to cope
- Custodians and Modern Family Businesses gave the highest priority to GHG issues and implemented most MMs

Overall, by providing a broad appeal of MMs, we found no evidence that any particular segment would be averse to implementation.

5.3 Policy tools

The major issue was awareness and knowledge of GHGs and opportunities for abatement. Given the strong focus on economic returns and the need to demonstrate cost-effectiveness, this should provide a key focus of any campaign to promote low-carbon opportunities; the contribution to the industry GHG targets would be a secondary driver.

Awareness can be driven at an industry wide level to capture incremental gains. Given the scepticism over the economic case, a series of case-studies might provide a useful vehicle for getting the message across. This could be promoted across a

broad range of media channels, from press articles to web based information and utilising current approaches such as Farming Futures.

To deliver step change in specific sectors using targeted MMs a more focused series of advisory programmes would be required with both demonstration (demonstration or monitor farms) to evidence local applicability, allow farmers to 'see with their own eyes' and to use peer pressure and norms where applicable.

Bringing GHGs into current advisory programmes should be a low cost operation, requiring limited changes to existing programmes and training of delivery agents. The RDPE is already funding relevant projects, for example the 'Landskills' projects under measure 111 (Vocational Training) which provide training and in some regions monitor farms. Demonstration farms have been found to be very cost effective in evaluations and are an established approach.

Farmers were anxious they may do the right thing for one policy only to break the rules on another. With a range of policies related to cross compliance and COGAP for example, they see further policy as likely to bring complications, whether it is voluntary or regulatory. This issue needs to be explicitly addressed and there may be some rationalisation of advice delivery resulting from the current Task Force on Farming Regulation[5].

A model for targeted advisory programmes exists around issues such as improving water quality (ECSFDI). There is a large range of organisations able to provide advice, as clearly indicated in FF0202. Further, research organisations, trade and levy bodies can all able to contribute to a co-ordinated programme where there is wider benefit e.g. in terms of sector CSR, supply chain efficiency etc.

5.4 Limitations and need for further research

While the number of farmers consulted in this study was small, the interface with AC0222 means that we can have confidence in attitudes to the mitigation methods across key sectors. However, we suggest the behavioural analysis of motivations and barriers is less reliable due to the sample size and the focus on a wide range of MMs. As such, follow up work to test attitudes to uptake of key methods in specific sectors would be valuable and allow policy makers to refine the approach.

There are also outstanding questions on the risks associated with some of the more promising methods, notably clover in less intensively managed grassland, uptake of improved genetics in the cattle and sheep sector and the scope for producing low-N crops such as triticale. This does not constitute a commitment to new R&D but rather bringing together a compelling case – economic and environmental – for uptake and combining with an effective knowledge transfer programme. Key issues for inclusion are:

- The extent to which new varieties of clover are easier to establish and manage than those with which many farmers have had past experience;
- The economic value of high EBV livestock, including market acceptability and management considerations;
- The market for low-N crops such as triticale for both biofuel and feed use to highlight the economics and management considerations

[5] http://ww2.defra.gov.uk/2010/07/09/farm-review/

Appendix 1: Bibliography

Agriculture Industry GHG Action Plan, 2010. A framework to reduce emissions from agriculture in England by 3m tCO_2e per annum from a 2008 baseline by the third budget period, 2018-22ACCTF, (10th February 2010), *Agricultural Industry GHG Action Plan: Framework for Action,* NFU, CLA, AIC. [Online] Available from: www.nfuonline.com/Our-work/Environment/Climate-change/GHG-emissions---reducing-agriculutral-emissions/ [Date accessed: 11.04.2010]

ADAS Evaluation of the Forward Farming Pilot Demonstration Farm Project Defra 2004

Appleton A F, How New York City used an ecosystem services strategy carried out through an urban-rural partnership to preserve the pristine quality of its drinking water and save billions of dollars. Forest Trends, Tokyo November 2002

Dampney P, Precision in arable farming – current practice and future potential, HGCA R&D Conference 28-29 Oct, Belton Woods, 2009)

DECC 2009 Carbon Valuation in UK Policy Appraisal: A Revised Approach

DECC (2009) *The UK Low Carbon Transition: National Strategy for Climate and Energy.* Department of Energy and Climate Change [online] Available from: http://www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx [Date accessed 20.04.2010]

Defra 2004 Farm classification in the United Kingdom,

Defra 2007a, SFF0602 market mechanisms for reducing GHG emissions from agriculture, forestry and land management

Defra 2007b, AC0206, a review of research to identify best practice for reducing Greenhouse Gases from agricultural and land management

Defra (2008a) *UK Marginal Cost Curves for the Agriculture, Forestry, Land-use and Land-use Change Sector out to 2022, with Qualitative Analysis of Options to 2050.* Defra [Online] Available from: www.knowledgescotland.org/images_db/ukmarginalabatementcostcurves.pdf [Date accessed: 10.04.2010]

Defra (2008b) *Understanding behaviours in a Farming Context:* Defra. [Online] Available from: http://www.defra.gov.uk/evidence/statistics/foodfarm/enviro/observatory/research/documents/ACEO%20Behaviours%20Discussion%20Paper%20(new%20links).pdf [Date accessed 10.04.2010]

Defra (2009a) *Analysis of Policy Instruments for Reducing GHG Emissions from Agriculture, Forestry and Land Management RMP5142.* Defra [Online] Available from: www.defra.gov.uk/foodfarm/landmanage/climate/documents/climate-ag-instruments.pdf [Date accessed: 11.04.2010]

Defra (2009b) *Energy Use on Farms: Results from the Farm Business Survey, 2007/08.* Defra [Online] Available from:

http://www.defra.gov.uk/evidence/statistics/foodfarm/farmmanage/energy/index.htm [Date accessed: 10.04.2010]

Defra (2010a), *Climate Change Plan.* Defra [Online] Available from: www.defra.gov.uk/environment/climate/documnets/climate-change-plan-2010.pdf

[Date accessed: 10.04.2010]

Defra (2010b) Agricultural advisory services analysis, FF0202.

Garforth C et al. (2006) *Research to Understand and Model the Behaviour and Motivations of Farmers in Responding to Policy Changes (England)* [online]. Available from: https://statistics.defra.gov.uk/esg/reports/Farmer%20Behaviour/default.asp

[Date accessed 20.4.2010]

NERA (2007): Market Mechanisms for reducing GHG emissions from Agriculture, Forestry and Land Management, SFF0602 report for Defra, September 2007

OPSI (2008), *Climate Change Act* Office for Public Sector Information [online] Available from: http://www.opsi.gov.uk/acts/acts2008/pdf/ukpga_20080027_en.pdf [Date accessed: 14.03.2010]

Defra project AC0221: Scoping the Potential to Reduce GHG Emissions Associated with N Fertiliser Applied to Arable Crops. From 2009-2010. Project description available from: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17109#Description

Defra Project AC0222: Feasibility of GHG Mitigation Methods. From 2009-2010. Project description available from: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17110#Description

Defra project RMP 4950. UK Marginal Abatement Cost Curves for the Agriculture and Land Use, Land-Use Change and Forestry Sectors out to 2022, with Qualitative Analysis of Options to 2050. SAC report available from:

http://www.knowledgescotland.org/images_db/ukmarginalabatementcostcurves.pdf

Appendix 2: Mitigation Methods

Table 10 sets out the full list of mitigation methods considered in the study. They have been classified as incremental (I) or step (S) change, according to the extent of degree of shift from the current position.

Table 10: Full list of Mitigation Methods

All farm types	
Avoid Excess N MMs	
1	Use RB209, PLANET or another similar tool to work out how much nitrogen to apply (I)
2	Calibrate your fertiliser spreader every year (I) to (S)
3	Take into full account the amount of nitrogen supplied by manure when deciding how much mineral nitrogen to apply (I)
4	Measure soil nitrogen supply before deciding how much nitrogen to apply (S)
5	Use precision farming techniques (S)
N timing MMs	
6	Avoid applying mineral nitrogen fertiliser before the crop starts growing in spring (I)
7	Avoid applying slurry / manure before the crop starts growing in spring (S)
8	Don't apply mineral nitrogen for at least 5 days after applying manure (I)
9	Spread the application of mineral nitrogen over 2 or 3 applications rather than just one application (I)
10	Don't apply mineral nitrogen for at least 5 days after heavy rain (I)
11	Grow triticale instead of wheat either for the animal feed market on or off farm or as an energy crop for the biofuels industry(S)
Dairy and cattle & sheep only	
12	Put your manure into an anaerobic digester either on farm or somewhere else (S)
13	Determine exact nutrition requirements for the desired level of production (I) Dairy – balance forage and starch intake Beef and sheep – feed to finish in optimum time
14	Introduce clover – white for longer term leys, red for short term leys (S)
15	Breeding Dairy - Seek breeding characteristics (high Profitable Lifetime Index, PLI) Beef - Seek breeding characteristics (high Estimated Breeding Value, EBV) Sheep – Seek to improve optimum productivity: >160 lambing % (I)
Dairy	
16	Covering slurry tanks to reduce ammonia and secondary emissions (S)
Cattle & sheep only	
17	Growth promoters (Ionophores) e.g. Monensin S

Appendix 3: Industry Day and Workshop details

(a) Industry representative attendance at Industry Day: The Royal Pavilion, Stoneleigh Park, 18th May 2010

Table 11: Industry representative attendance at Industry Day

Stakeholder group	Attended	Telephone top up
DairyCo	2	
EBLEX		1
HGCA		1
NFU	2	
CLA		1
National Trust		1
RSPB	1	
National Park Authority		1
Severn Trent Water		1
Environment Agency (EA)	1	
Co-operative Farms		1
AIC	1	
Natural England (NE)		1
Total	**7**	**8**

(b) Workshop attendance and characterisation

Table 12: Farmer participation in information gathering

Sector	Workshop attendance	Telephone top up	Total
Arable	14	3	17
Livestock	7	8	15
Dairy	7	8	15
Total	**28**	**19**	**47**

Table 13: Distribution of farmers by segmentation type

	Frequency	%	Defra % (2008b)
Custodians	14	30	23
Modern family businesses	14	30	41
Pragmatists	9	20	22
Challenged enterprises	5	11	8
Lifestyle choice	4	9	6
Total	**46**	**100**	**100**

Appendix 4: Commentary on individual MMs

Farmers understanding of MMs and GHGs *per se* were found to be at a low level in all three projects and in all sectors. Abatement estimates from AC0222 will be inserted when available.

1. Use RB209 or similar tool to work out how much N to apply

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
High in arable, lower on dairy and livestock	Significant		All	Dairy and livestock	All

In AC0222 and FF0201, this MM was found already to have a high level of implementation. A minority of dairy farmers said they would like to see economic justification of more detailed management of mineral N management and on beef and sheep farms there is a major challenge due to the low current usage and the fact that the major crop is grass. The farmers felt that minor variations in application made little difference to productivity.

2. Calibrate your fertiliser spreader every year

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
High in arable. Lower on dairy and livestock, but high in contractors	Significant on grassland, but uncertainty over effectiveness		All	Dairy and livestock	All

This was found to be popular on arable and dairy farms either by farmers themselves carrying it out or where contractors do the spreading. Responses in the livestock workshop show that unless livestock farmers use a contractor, they are unlikely to carry out much more than a cursory check that the right amount is being spread.

"I only grow grass and don't use a lot of nitrogen. I calibrate my spreader by seeing how much fertiliser I use in one field and then adjust it if I need to. I can't afford to spend money on calibration".

– Livestock Farmer

"If calibration becomes a requirement of farm assurance schemes, it will be another licence to print money for the people doing the testing and we will have to pay".

– Arable Farmer

3. Take into full account the amount of nitrogen supplied by manure when deciding how much mineral nitrogen to apply

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
High in all sectors	Some potential on dairy where greater analysis and accuracy required		MFB & lifestyle choice	Dairy and livestock	All

Better economic justification was found to be required for this method in AC0222 and FF0201 also identified this as an issue, although farmers in the livestock workshop said that use of this method is unlikely on LFA beef and sheep farms due to the presence of shallow soils over rock, where the response to applied N was limited.

All farmers were keen to take account of manure N in their fertiliser practice. However this was generally on a rule of thumb basis with none of the attendees having manure samples analysed. Similarly, almost no delegates measured soil mineral nitrogen.

4. Measure soil nitrogen supply before deciding how much nitrogen to apply

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
Low	Low, this is seen as an unnecessary cost		All	Dairy and arable	All

In both FF0201 and AC0222 farmers reported that better economic justification is required for this MM to be applied. In FF0201, the practice of estimating soil nitrogen through use of, for example, RB209 was widely implemented.

5. Use precision farming techniques

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
Low	Low, this is seen as an unnecessary cost in most cases		All	Dairy and arable	All

Arable farmers were well disposed to precision farming techniques where it could be shown to be cost effective, but the effect on GHG abatement was viewed as a consequential benefit.

Many dairy farmers used contractors for fertiliser spreading and they were similarly equipped with precision farming equipment, but livestock farmers used far less and then always through contractors. This latter comment suggests that as well as the farmers and managers, there is a need to engage and communicate with the contracting community to ensure the widest adoption.

Having discussed it in the workshops, half the arable farmers said they would not change, a third said they would carry out more and two said they would introduce the MM. However, the majority of dairy and livestock farmers had no intention of changing, although a small minority would consider introducing it.

These views expressed in the workshops concur with those of the industry representatives, as well as other professionals (Dampney 2009), that is the limitation of precision farming to land of variable soil type.

6. N timing MMs:

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
High. Farmers feel they do a good job balancing weather, timing and amount	Low, because farmers seek to minimise risk		All	Dairy and arable	All

Measures include:

- Avoid applying mineral nitrogen fertiliser before the crop starts growing in spring
- Avoid applying slurry / manure before the crop starts growing in spring
- Don't apply mineral nitrogen for at least 5 days after applying manure
- Spread the application of mineral nitrogen over 2or 3 applications rather than just one application
- Don't apply mineral nitrogen for at least 5 days after heavy rain

AC0221 estimated that the abatement potential of increased efficiency of N use could reduce English agricultural emissions by 4%. In AC0222, farmers expressed the need for more evidence of impact and economic justification in order to increase implementation.

In FF0201, farmers concurred with AC0222, adding that timeliness and weather factors were over riding in their decision making process. The dairy farmers all said that manure timing is driven by NVZ rules in those areas. Outside NVZs, the dairy farmers and the livestock farmers had issues with the economics of slurry storage and spreading in spring. This was because of clashes with other management tasks, such as lambing

During the workshops all delegates pointed out that they strive very hard to achieve accuracy (timing and quantity) in using mineral N because it is such an expensive resource.

7. Grow triticale instead of wheat

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
Low	High, but needs market driver and local evidence		All	Dairy and arable	All

A number of farmers in all sectors knew about triticale. In both FF0201 and AC0222, farmers had mixed experiences of growing it in recent years. In all cases, this had been as an alternative feed grain to wheat. However, for the same reasons, triticale could be used as an alternative to wheat as an energy crop for the biofuels industry.

When discussing the MM in the workshops, farmers identified a range of major barriers before they would adopt the MM. These included that they would require more evidence of its suitability on the farm, as well as its viability in the market. As it stands, the majority of

farmers do not grow triticale and are not prepared to change without the above barriers being addressed.

8. Anaerobic digestion

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
Low	Low. Capital cost and complexity are major disincentives		All	Dairy and arable	Large

In the workshops, this was seen as a major step and unlikely on most farms, although in FF0201 and AC0222, there was a lack of clear and simple information. On-farm anaerobic digesters were not a popular option among respondents. This option was seen as something for a large operator or non farming operator to be concerned with. No farmers were involved in AD at present and only one would consider looking into it.

9. Use ration formulation

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
High	Needs to re-focus to cover GHG, not just production		All	Mainly dairy and some livestock	All

During discussions in the workshops, farmers felt that they were implementing this to a high level either by formal computer programs or through experience although AC0222, a better understanding of the opportunities to improve diet formulation would be required. This reflects the situation that farm assurance agreements require dairy farmers to plan rations objectively. However, two of the dairy farmers felt they could go further than the farm assurance agreements require by exploring rationing in more detail to increase efficiency.

10. Introduce clover

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
High, most farmers with grass use it	High, but needs knowledge driver and local evidence		MFB & lifestyle choice	Dairy and livestock	All

This was viewed very favourably by livestock and dairy farmers who agreed with the comments in AC0222 that it should be an option in stewardship schemes. However, this would not be possible for MMs with no income foregone (i.e. they result in the farmer saving or making money).

"A lot of farmers don't want to try clover because they think it will disappear after a couple of seasons, but new varieties are more competitive. More farmers would try clover if it was an option in Stewardship"

– Dairy Farmer

At the industry day, a comment was made that the use of clover has increased since the rise in fertiliser prices in 2008 (pers. comm. G Fisher June 2010).

11. Breed for both high productivity and long life

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
Moderate. Often carried out by rough calculations	High, but needs knowledge driver and local evidence		MFB & lifestyle choice	Dairy and livestock	All

This was discussed at some length in the dairy and livestock workshops. Farmers acknowledged the potential, but pointed out that many livestock farmers in particular select breeding stock on looks in spite of the work of EBLEX and DairyCo over the years. The response in AC0222 suggests that more evidence of economic impacts is required.

Almost three quarters of dairy and livestock farmers said they would maintain current breeding policy and the other quarter was prepared to consider changes. With respect to changing breed, dairy farmers were confident that current genetics offer all they need in terms of health and longevity. This contrasted with livestock farmers where the majority would be prepared to change if the benefits can be seen clearly.

12. Covering slurry tanks to reduce ammonia and secondary emissions

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
Low	Low, farmers do not see it as a solution to storage or GHGs		All	Dairy	All

During discussions in the dairy and livestock workshops, the covering of slurry tanks was seen only as a means of avoiding unnecessary filling of the tank by rainwater and the link with GHG mitigation was not recognised. This is because farmers could not see that it would be effective. None of the dairy or livestock farmers currently apply it and none would change.

"Covering slurry tanks doesn't reduce emissions unless you constantly pump off the methane. Without that, the only good it does is to reduce rainfall into the tank."

– Dairy Farmer

13. Use growth promoters

Level of uptake	Potential for further uptake	Estimate in AC0222	Segment	Sector	Farm size
Low	Low. Most farmers would not use it in current market			Livestock	All

No farmers use this at present due to restrictions from EU legislation. Most of the dairy and livestock farmers were not interested in this as an option because of negative associations in the minds of consumers with such techniques. However, a third of livestock farmers would be prepared to use it if the market conditions were positive.