Climate change mitigation options in the rural land use sector: stakeholders' perspectives on barriers, enablers and the role of policy in North East Scotland

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ABSTRACT

The rural land use sector could potentially mitigate a large amount of GHG emissions. Implementation requires the engagement of farmers and other land managers. Understanding the barriers and enablers for the uptake of these practices is essential both to inform policy-makers and to achieve effective policy outreach. In Scotland, the rural land use sector is subject to a greenhouse gas (GHG) emission reduction target of 21% by 2020 relative to 1990 levels. This study contributes to the body of research on stakeholders' perspectives about suitability of climate change mitigation practices at the regional level. Mixed-methods were used to collect the data, namely participatory workshops with scientists and relevant stakeholders, a farmer questionnaire, and focus groups with farmers. Findings show that farmers were mainly willing to expand the uptake of mitigation practices they were already implementing because they consider these are the most cost-effective. Barriers to the implementation of mitigation practices are mainly related to physical-environmental constraints, lack of information and education and personal interests and values. Similarly, enablers are also related to physical- environmental factors and personal interests and values.

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Economic incentives, voluntary approaches and provision of information have been identified by workshop participants as the most favourable approaches needed to promote the uptake of technically feasible mitigation practices. Farmers, however, consider that agriculture is a "special case" and should have not to comply with GHG emission reduction targets. Mitigation practices, should, therefore, be integrated with other initiatives.

Keywords: GHG emission targets, mitigation practices, barriers, enablers, policy.

1 Introduction

The European Union recommends that Member States provide information on the support for climate change objectives in line with the ambition to devote at least 20% of the European Agricultural Fund for Rural Development (EAFRD) to climate change mitigation and adaptation (Council of the European Union, 2012). Several studies have suggested technologies and practices to mitigate GHGs emissions from agriculture (e.g. Johnson *et al*., 2007; Freibauer *et al*., 2004; Ovando and Caparros, 2009; Powlson et al., 2008; Smith *et al*., 2008). In the UK, marginal abatement cost curves (MACCs) for agriculture and land use, land use and forestry have been developed (Macleod *et al*., 2010; Moran *et al*., 2008, 2011). These indicate the cost of reducing an additional unit of carbon equivalent emissions given the adoption of a certain mitigation practice, averaged across a range of farms. Although certain GHG mitigation options can be implemented with very low costs, or in many cases even with a net profit (Moran *et al.*, 2011; Smith & Olesen, 2010), these so-called win-win options are often identified at the national level and not always suitable at the regional or even farm level. Anastasiadis *et al.* (2012) distinguished between mitigation that is probable (likely to be implemented given current trends), and mitigation that is possible (while technologically feasible, is unlikely to be implemented given current trends). In the investigation of likely uptake of measures this distinction is crucial. Many studies focus mainly on technical mitigation potential rather than the socio-economic potentials but this do not reflect the real availability of land to implement mitigation practices, which can be affected by barriers such as tenurial status or the need for food production (Barnes and Toma, 2012; Reidy *et al*., 2008). Smith *et al.* (2007) and Smith & Olesen (2010) reviewed policy and technological barriers to the implementation of GHG mitigation options in agriculture from a farm level perspective. According to these authors, it is likely those barriers are highly regional and often even farm-specific depending on site specific factors, regional policy socio-economic and cultural conditions. This largely influences farmers' decision making in relation to the implementation of mitigation practices. Dandy (2012) organised the extent of influences on land-manager decision making in four categories: economic, social, physical – environmental and operational. Hallam *et al.* (2012) reviewed and classified the key enablers of decision making processes and farmers' behaviours in external factors, economic factors internal factors and social factors. The combination of economic, social and physical-environmental factors in a particular pattern reflects different farming styles, and these are said to explain the large homogeneity of farming that can be found in particular settings (van der Ploeg, 2010). Farming styles are also likely to affect GHG emissions from agriculture as well as the uptake of practices to mitigate these emissions.

Given the central role of the agricultural sector in Rural Development Programme spending, an understanding of how farmers would respond to climate change mitigation initiatives is required to inform effective outreach strategies (Arbuckle Jr. *et al*. 2013; Rejesus 2012; Barnes and Toma 2012). It is also essential to understand which policy mechanisms influence farmers' behaviour the most to ensure a high uptake of GHG emissions mitigation practices. This study aimed at contributing to the body of literature on stakeholders' perspectives on barriers, enablers and policy mechanisms regarding the implementation of GHG emissions in the rural land use sector. The definitions of perspectives, barriers and enablers were adopted from the Oxford online dictionary[2]. Therefore, perspectives were defined as the way farmers regard situations and facts, a point of view or a particular attitude towards something; barriers were defined as the circumstances or obstacles that prevent communication or progress; and enablers were defined as factors that cause particular phenomenon to happen or develop. Four main questions were investigated:

i. What are the current and preferred mitigation practices to be implemented in the future?
ii. What are the barriers and enablers to the uptake of mitigation practices?
iii. What are the most supported mechanisms to promote the uptake of suitable mitigation practices?
iv. What are farmers' perspectives on meeting the Scottish 2020 GHG emission reduction target in the land use sector?

[2] http://www.oxforddictionaries.com/

The study is built on the premise that a regional approach is an appropriate level to formulate suitable land-based mitigation strategies because it considers regional specificities in terms of biophysical conditions as well as behaviours, traditions and land use practices. Winter and Lobley (2009) recommended that local responses to climate change mitigation should not be neglected, and called for an emergent sense of place in agricultural, food, and land-based mitigation policy discourses. The North East of Scotland is the region chosen for this study because it provides a suitable study context to explore the challenges of adopting mitigation practices in the farm sector. Tackling climate change is regarded by the Scottish Government as the responsibility of all sectors of the economy, and the Scottish farm sector is advised to take steps to reduce GHG emissions (SRUC, 2013). The Delivery Plan for the Climate Change (Scotland) Act 2009 expects agriculture and agricultural land use to reduce their emissions in 2020 by 21%, compared to 1990 levels (Scottish Government, 2009a) and the Scottish Land Use Strategy emphasises that this sector should be part of the country's climate change mitigation strategy (Scottish Government, 2011). The Scottish policy also recognizes the effective uptake of low-carbon initiatives require local knowledge and local buy-in (RSE, 2011). Regional-level assessments are important because climate change scientists usually identify standard mitigation practices which might be applicable to the whole country but are not suitable at the local level. Different regions have different land use systems depending on the combination of local skills, culture and tradition. As a consequence, local barriers and enablers need to be identified in order to design mitigation practices which are consistent with the different systems. This information is essential to upscale regional policies at the European Union policy level. The methodology provided in this study can be applicable in other regions of the world to assess stakeholders' perspectives on the implementation climate change mitigation practices in the rural land use sector.

2 Methodology

2.1 Study region

North East Scotland (Aberdeenshire, Aberdeen, Moray council areas) was the study region chosen because it represents a diversity and intensity of agricultural use types, different styles of forestry, protected conservation areas and substantial areas of game management, which endow it with considerable diversity. Also, since most Scottish land uses, farming systems and farming sizes can be found in North East Scotland, at different intensities, this makes the region a microcosm of Scotland's land use sector. The region also contains a wide variety of soils, from carbon-rich soils to mineral soils and a range of intensities of land management practices. A further reason is the expressed aspiration of the largest administrative district in North-East Scotland by land area (Aberdeenshire) to become carbon-neutral in the medium term (by 2030), which cannot be achieved without land use sector engagement.

2.2 Data collection on GHG mitigation practices from the rural land use sector

Reducing GHG emissions from agriculture can be done changing the level of an activity, by increasing the efficiency of production through a change in management practices, i.e., increasing yield without changing emissions, or by increasing carbon storage in soil and biomass (e.g. wood) (Smith *et al.*, 2008). Avoiding or displacing emissions is another way of reducing GHG emissions from agriculture (McCarl and Schneider, 2001; Smith *et al.*, 2008). The potential mitigation practices for the rural land use sector in North East Scotland, as well as the barriers and enablers for its uptake were explored through a thorough literature questionnaire of academic and grey literature. This was followed by the application of qualitative (participatory workshops, focus groups, farmer questionnaire) research methods. Brannen (2005) considers that mixed-methods research has several advantages, namely the elaboration and expansion of the data analysis, the possibility of pursuing hypotheses arisen during the use of a first method, the complementarity of data obtained with different methods which, together, create a bigger picture of the object of research, and the fact that any contradictions can be explored in further research. The methodology undertaken according to each research tool is described below.

2.2.1 Participatory workshops

Two participatory workshops with scientists and relevant stakeholders were held. In the first workshop, participants were scientists in soil science, bio-energy, ecosystem services, deer management, ecology, upland management, rural development, forestry, ruminant nutrition, biodiversity and grasslands. In the second workshop, stakeholders were estate owners, agricultural consultants, industry and farming sector representatives and business advisors. *Stakeholders* are those affected by the decisions and actions taken by decision-makers and those who have the power to influence the policies outcome (Freeman, 1984). The objective of the participatory workshops was to provide an insight into the mitigation practices that were already implemented, its suitability for the region, the barriers and enablers, and the policy mechanisms to promote the uptake. Participants in the workshops were represented with letter **PW** in Tables 2 and 3 of the results section.

Participants were selected by snowball sampling, i.e., a number of initial contacts were made and from these, the names and addresses of other people who fulfilled the sampling requirements were collected. Snowball sampling is usually placed within a wider set of methodologies that takes advantage of the social networks of identified respondents, which can be used to provide a researcher with an escalating set of potential contacts (Atkinson and Flint, 2004). According to Faugier and Sargeant (1997), the strategy has been utilized primarily as a response to overcome the problems associated with understanding and sampling populations which are difficult for researchers to access, as in this case, the farm population in North East Scotland.

The workshops lasted approximately two hours and participants were asked:

1) To identify technically feasible GHG mitigation practices for the rural land use sector;
2) To rank 27 practices according its suitability in North East Scotland;
3) To identify the barriers to the implementation of the mitigation practices;
4) To identity the enablers to the implementation of mitigation practices;
5) To point out the most suitable policy mechanisms to encourage the uptake of mitigation practices.

Technically feasible GHG mitigation practices were defined as those capable of providing a reduction in GHG emissions measured in $CO_2eq\ ha^{-1}yr^{-1}$ (carbon dioxide equivalent per hectare per year) or CO_2eq animal^{-1} yr^{-1} (carbon dioxide equivalent per animal per year). It was assumed these should not have a negative impact on agricultural production. The discussions were recorded with a digital dictaphone and subsequently transcribed. The NVivo9 software was used to code, analyse, and interpret the qualitative data collected (QSR international, 2014[3]). To follow-up the results from the discussion undertaken with scientists and stakeholders, a farmers' questionnaire was undertaken.

[3] http://www.qsrinternational.com/products.aspx

2.3 Farmer questionnaire

The objective of the farmer questionnaire was to assess current and potential mitigation practices adopted by North East Scotland farmers, as well as farmers' perspectives about the enabling factors for the adoption. The participatory workshops served as an information source to design this questionnaire which included 27 mitigation practices related to cropland and grassland management, soil-carbon sequestration, livestock management and above-ground carbon sequestration (See Appendix 1). Practices were selected from Moran *et al.*, (2008), Smith *et al.* (2008) and Radov *et al.* (2007). Farmers were asked to signal from a list of practices those that they had already implemented on their farms. They were also asked to indicate the top three most effective mitigation practices to implement if it became compulsory to reduce farm GHG emissions by 21% in 2020, and to justify their choice. Several closed questions aimed at collecting general information about the respondents (e.g. postcode, type of farm, size of farm) were also included in the questionnaire, as well as a question about the use of carbon footprint as proxy to understand farmers' awareness on climate change. Farmers' responses were represented with letter **FQ** in Tables 2 and 3 of the results section.

Convenience sampling, a type of non-probability sample in which a population is selected because it is readily available and convenient, was the method used. The sample included farmers attending local livestock marts and farmers meetings and members of the Scottish Land and Estates, a landowners' association which promotes the benefits provided by land-based businesses. Convenience sampling was used because of time constraints, ease of gaining data and quickness in getting a significant number of responses in a short period of time. Seventy-five per cent of the people approached in the livestock marts were farmers and agreed to complete the questionnaire. Members of the Scottish Land and Estates responded an online version of the questionnaire. In total, 99 questionnaires were completed.

2.4 Focus groups with farmers

To add depth to the results of the questionnaire, three focus groups with farmers were held. The objective of these focus groups was also to investigate whether farmers agreed with the list of suitable GHG mitigation practices selected by the stakeholders who attended the participatory workshops or not. Mixed and arable farmers attended the three focus groups.

The focus groups were divided into three main parts:

1) Farmers identified feasible GHG mitigation practices for the rural land use sector;
2) Farmers discussed barriers and enablers towards the implementation of mitigation practices identified;
3) Farmers examined whether a 21% GHG emission reduction in the rural land use sector by 2020 was possible or not.

To ensure the successful recruitment of farmers, the focus groups were integrated into the monthly farmers meetings organised by the Scottish Agricultural College (now Scotland's Rural College) and National Farmers' Union Scotland (NFUS). The discussions were recorded with a digital dictaphone and lasted between one and two hours. They were also transcribed and organised into topic areas and key-themes using NVivo9 software.

2.5 Analytical framework

Barriers, enablers and policy mechanisms identified by the stakeholders and collected during the farmers' questionnaire, workshops and focus groups were categorized and analysed through an analytical framework adapted from those presented by Dandy (2012), Hallam et al. (2012) and Smith & Olesen (2010). The description of each of these barriers, enablers and policy mechanisms is presented in Table 1.

[Table 1 here]

3 Results

3.1 Current and future GHG emission mitigation practices

The main method used to assess the current and potential implementation of mitigation practices in North East Scotland was the farmers' questionnaire. According to data collected during the questionnaire, all farmers in the study sample were undertaking at least one of the 27 GHG mitigation practices listed in the questionnaire. The top three practices currently implemented by farmers were using all the manure or slurry produced on the farm as fertiliser, "matching the timing of mineral fertiliser application when the crop will make the most out of it" and using biological fixation to provide nitrogen inputs (Figure 1- A). These three practices are related to the reduction of nitrogen fertiliser application. It was verified that some livestock-related practices such as dietary additives, animal breeding (e.g. adopting genetically improved animals) and manure management (e.g. covering slurry tanks or lagoons) were not very popular amongst farmers of the study sample, with only 10% saying they were currently implementing some of them. It is possible that farmers using high quality breeding stock with high Estimated Breeding Values (EBVs) do not recognise this as a mitigation practice. In contrast, 46% of the farmers in the study sample said they were currently increasing the concentrate ration in the cattle diet (Figure 1- A). In relation to the future adoption of mitigation practices, those who responded to the questionnaire signalled they would expand the area of biological fixation with clover, reduce nitrogen fertiliser and adopt new plant varieties that can produce the same yields using less nitrogen (Figure1-B). The least preferred mitigation practices to be adopted in the future were using dietary additives, managing organic soils, using genetically improved animals, covering slurry tanks and lagoons, and feeding cows with bovine somatotropin, a feed additive to increase livestock productivity and decrease CH_4 emissions, which is currently banned in the European Union (Figure1-B). It can be noticed that, the most currently implemented mitigation practices are also those farmers would be willing to implement in the future.

In the participatory workshops, stakeholders considered that, from the 27 mitigation practices they were presented with, the most suitable to be implemented in North East Scotland were (highest ranked first):

- Precision farming
- Biological fixation with clover
- Genetic improved animals
- Mixed farming systems
- Peatland restoration
- Woodland planting (including hedgerows; agroforestry)

3.2 Barriers to the uptake of GHG emission mitigation practices

During the participatory workshops the stakeholders pointed out the barriers to the implementation of the mitigation practices they considered the most suitable for the North East Scotland. In the focus groups, farmers were also given the opportunity to present their perspective regarding the barriers to the implementation of those practices. The barriers pointed out by farmers, scientists and stakeholders are presented in Table 2. Personal interests and values in relation to the uptake of mitigation practices were literally extracted from the transcripts. The barriers identified by scientists and stakeholders are marked with an **PW** (participatory workshops)**,** those identified by farmers in the focus groups are marked as **FG** (focus groups) and those pointed out in the farmers' questionnaire are marked as **FQ** (farmer questionnaire).

[Table 2 here]

3.3 Enablers for the uptake of mitigation practices

Participants at the workshops and focus groups pointed out the enablers to the implementation of the mitigation practices in North East Scotland. Farmers were also asked to do the same in the farmers' questionnaire. Similarly to the barriers, the enablers identified by scientists and stakeholders are marked with an **PW,** those identified by farmers in the focus groups are marked as **FG** and those from the farmers' questionnaire are marked as **FQ** (Table 3).

[Table 3 here]

3.4 Policy mechanisms to increase the uptake of the mitigation options

In the participatory workshops scientists and stakeholders were asked about what should be done to increase the uptake of the mitigation practices they considered the most suitable for the North East Scotland. The most suggested approaches were economic incentives (e.g. grants for woodland planting), voluntary approaches (e.g. machinery rings) and education (e.g. monitoring farms).

[Table 4 here]

3.5 Potential for the rural land use sector to deliver GHG emission reduction target by 2020

In the focus group, where this question was discussed, farmers revealed they felt the pressure to do something about climate change mitigation and that they do not want such responsibility. The lack of interest or awareness about the need of reducing GHG emissions in the rural land use sector can also be deduced from the fact that only 11% of the farmers questioned said they had already used a carbon footprint calculator.

Farmers saw themselves as food producers and therefore as a special case. There were concerns that increasing the pressure on agriculture to mitigate climate change would drive farmers out of business and impact negatively on food production unless there were financial incentives. Farmers also assumed they were the "*only ones left to do it*" ('farming') because "*the youngsters are in reducing numbers and are walking away*". They argued that their crops and meat stored carbon and this should be accounted for climate change mitigation as well as the carbon sequestered in grasslands. It was largely agreed that a 21% GHG emissions reduction relative to 1990 was not going to be achieved by 2020, unless incentives were

4 Discussion

Identifying the mitigation practices farmers are most likely to implement and understanding the range of factors influencing farmers' behaviours can contribute to a more effective alignment between policy-makers' objectives and farmers' objectives. This section discusses the implications of our findings in five areas: current and future mitigation practices, barriers to the implementation of mitigation practices, enablers, policy mechanisms available to promote the implementation of mitigation practices and meeting of the Scottish 2020 GHG emission mitigation target.

4.1 Current and future mitigation practices

Among the main practices implemented by farmers that responded to the questionnaire undertaken was 'using biological fixation with clover to provide nitrogen inputs' (Figure 1-A). This practice would almost certainly be expanded or initiated by most farmers questioned if it was compulsory to reduce farm-related GHG emissions (Figure 1-B). Both current and future practices to be implemented are related to reduction of mineral nitrogen (N) fertiliser this suggesting, understandably, that mitigation practices which are effective and save them money are most favoured. However, farm woodland planting, which has been considered a cost-effective option to mitigate GHG emissions (Nijnik and Bizikova, 2008; Moran, 2008) was one of the least preferred practices by farmers who responded to the questionnaire and those who attended the focus groups. 'Using all the manure or slurry produced on the farm as fertiliser and 'matching the timing of nitrogen (N) fertiliser application when the crop will make the most out of it', were two other top practices widely implemented already (Figure 1-A) and which farmers would potentially expand in the future (Figure 1-B).

The results from the questionnaire on current and future mitigation practices to be implemented in the future suggest that farmers were only willing to mitigate GHG emissions with the minimum effort and do not want to embark on new practices, which they do not know much about. This is possibly explained by farmers' attitudes to risk, the requirement for knowledge, or farmers' consistency with traditional practices (Smith *et al.*, 2007).

4.2 Barriers to the implementation of mitigation practices

Physical-environmental constraints and lack of information and education were the most commonly mentioned barriers. Dandy (2012) found that land capability, specially productivity, location, climate and environmental quality are important to land managers. One of the variables most commonly linked with land-management decisions is the size of the farm. In fact, farmers considered that precision farming, the highest ranked practice by workshop participants, is not efficient in small-scale farming (Table 2). Climate suitability is another important consideration for land managers (Dandy, 2012). Climate constraints were mentioned in relation to the implementation of biological fixation with clover, minimum/zero tillage and matching the time of organic fertiliser application with the time the crop take the most out of it. This last practice is already included in the list of Good Agricultural and Environmental Condition (GAEC) requirements with which compliance is required to receive the Single Farm Payment. Although, this regulatory obligation might be responsible for the high percentage of farmers saying they currently implement it (Figure 1-A), in the focus groups farmers revealed the weather dictates when they apply organic fertiliser and not the official dates (Table 2). This suggests that compliance might be difficult to monitor.

Lack of information and education was another constraint mentioned by stakeholders and farmers in the focus groups. This constraint was mainly described in relation to biological fixation with clover which means that there are still potential for its expansion. This was the most popular mitigation practice to be implemented in the future by the farmers questioned at the marts (Figure 1-B) and it might be the lack of skills that is preventing its expansion. Similar findings were reported by Barnes *et al.* (2010) in relation to farmers' perception of biological fixation using clover and the current and future implementation of this practice. Biological fixation with clover is normally part of a rotational farm system and this type of management requires traditional knowledge and skills which farmers do not have anymore because they are too specialised in food production. The co-benefits (e.g. reducing the need of nitrogen mineral fertiliser) of using biological processes to fix carbon should, therefore, be promoted to increase its uptake.

In relation to personal interests and values, it is worthwhile mentioning the negative attitude of farmers towards woodland planting (Table 2). Scientists, who considered this practice very suitable for North East Scotland, also recognised that farmers do not want to be foresters and that it might look like an imposition to tell them where to plant trees. A report from the Woodland Expansion Advisory Group (WEAG, 2012) concluded that planting levels in recent years have been at their lowest level for half a century, and that there is a deep cultural divide between forestry and farming. Lawrence and Dandy (2014) concluded that in the UK private landowners have their own objectives, and respond (or not) to a wide range of policies, forestry being one of their least preferred objectives. Previous research on farmers' attitudes to tree planting and forestry incentive schemes in the UK found out that farmers have little interest in planting, incentives are inadequate and tenure conditions pose difficulties for tenant farmers if they want to plant trees (Crabtree et al., 2001). Curiously, none of the farmers in the focus groups mentioned that the reason why they do not plant trees was the lack of grants or incentives.

4.3 Enablers to the implementation of mitigation practices

The main enablers to the implementation of mitigation practices were the decrease in the operating costs, the practicalities of conducting land-management (operations), physical-environmental factors and farmer's personal interest and values. Operational costs (reducing costs and increasing profit) were other common reasons pointed out by farmers to explain why the top three mitigation practices in Figure 1-B were those preferred to be adopted or expanded in the future. This could suggest that for the least preferred mitigation practices some sort of incentive would be needed to increase the adoption. In the focus group one farmer pointed out he only plants trees because he benefits from forest grants (Table 3). However, some authors (e.g. Neumann *et al.*, 2007; Amacher *et al*., 2004) have shown that economic incentives alone are unlikely to change land-manager behaviour. According to Dandy (2012), farmers might engage with different incentives in different ways depending on who provides the incentives, the conditions associated to these incentives or their experiences with it. In fact, farmers did not mention that the lack of economic incentives was a barrier to the implementation of mitigation practices (see table 2).

Operational and physical-environmental factors were also important for the adoption of several mitigation practices. "*Easiness of implementation*" and "*farm characteristics*" were mentioned as reasons for the adoption of several practices (Table 3). This suggests that for the first case, labour and hardware needed to implement the practices were available and, in the second case, the practices were suitable for the physical/environmental conditions of the farm (e.g. "*Wind turbines can be implemented in the poorest ground*"; *Hedgerows improve the microclimate in the field*" – Table 3). It can also be noticed the personal interests and values for practices such as renewable energy ("*If every farmer could have one* (wind turbine) *they would be delighted*") and ionophores ("*Definitely happy to adopt*"). Interestingly, this mitigation practice received more support from farmers attending the focus groups than those questioned in the marts. Although ionophores are forbidden in European countries, farmers attending the focus groups said they have been asking for this feed additive for long time.

4.4 Policy mechanisms to promote the implementation of mitigation practices

Workshop participants (scientists and stakeholders) considered the provision of incentives would promote the adoption of mitigation practices and from the farmers' side there was slight evidence these could be effective in the case of biological fixation with clover and woodland planting (Table 2 and 3). Using financial incentives and market-based instruments would be suitable to promote peatland restoration, since this practice produces public benefits (e.g. carbon storage) which have low or no direct market value. Scientists pointed out these mechanisms would be important to restore the large area of abandoned peatland in North East Scotland (Table 4).

Streck *et al.* (2011) consider that a mix of instruments and governance arrangements that include both positive incentives, regulations and sanctions is needed to achieve the multiple objectives of food security and effective GHG mitigation. The Royal Society of Edinburgh (RSE) (2011) suggests that policy levers[4] involving both incentives and education are required in order to induce the required changes in behaviour. Collins *et al.* (2003) pointed out that policies can be based on 'carrots' (grants), 'sticks' (taxes) and 'sermons' (persuasion).

In relation to education and provision of information there were some cases (e.g. precision farming; biological fixation with clover) where farmers pointed out that lack of knowledge to implement the practices. This coincided with workshop participants' suggestion of the need for information provision (Table 2 and Table 4). In Scotland, Farming for a Better Climate

[4] Policies are considered as levers if they can pull to change the behaviours of individuals and groups.

(FFBC) website[5] is a mean of increasing awareness by providing advice on cost‑effective GHG emission mitigation practices that can be undertaken by farmers. The Report on Proposals and Policies (Scottish Government, 2011) recommends the creation of a target for the number of farm businesses that adopt measures from the FFBC. This strategy for spreading information between farmers may, however, exclude those with no internet access.

4.5 Potential for the rural land use sector to deliver GHG emission reduction target by 2020

Farmers' view of agriculture as a "*special case*", which arose at the focus groups, was also found by Clark and Johnson (1993:15) in Scotland: "*farmers displayed deeply embedded psychological and moral reasons for focusing on food production* (…)". The low uptake (11%) of carbon footprint calculators by the farmers questioned at the livestock marts was already an indicative that farmers might have not be highly engaged with climate change mitigation practices. Other studies found that less than 50% of the farmers questioned thought the temperature was going to increase in the future (Barnes and Toma, 2012) or that climate change had been scientifically proven (Rejesus, 2012). These results could be due to farmers' lack of awareness or interest, or due to psychological distance, which refers to the perception that something, in this case climate change, will occur at a distant point in time, far away geographically, or will affect people unlike oneself and in less developed countries (Evans *et al*., 2014). Greater psychological distance constrains the uptake of climate change mitigation practices because the more farmers believe climate change is distant, the less likely they are to take action here and now.

5 Conclusion

Confronting and mitigating climate change are among the major challenges currently faced by humanity. Agriculture plays a significant role in mitigating climate change both by reducing GHG emissions and sequestering carbon dioxide. Given the required GHG emission reduction targets set by the Climate Change (Scotland) Act 2009 their achievement will be contingent on farmers responding. This study has highlighted the current and potential mitigation practices to be implemented in the future (Figure 1-A, 1-B), the barriers and

[5] http://www.sruc.ac.uk/climatechange/farmingforabetterclimate/ (Last accessed 06/06/2014).

enablers towards the adoption of mitigation practices (Tables 2 and 3), the preferred policy mechanisms to promote the adoption of mitigation practices (Table 4) and the general view of farmers about the meeting of the GHG emission reduction target in 2020.

It has been shown that, in North East Scotland, farmers are already undertaking some mitigation practices, albeit sometimes for other reasons than climate change mitigation (e.g. GAEC). The reduction in emissions sought in by policy will be hard to obtain given the fact that current practices are those that farmers seem to be more willing to implement in the future. Farmers seem to accept some widely practiced low cost activities such as use of clover, but are often antagonistic to tree planting. But if farmers have recognised that some mitigation practices would lower their operational costs (Table 3), physical-environmental constraints and lack of information/education seem to be preventing them from the implementation of those practices. It was suggested that economic incentives would be needed to promote the uptake of suitable mitigation practices in the North East Scotland (Table 4) and there was slight evidence this would be effective. The policy and advisory sectors thus face a major challenge in designing and delivering appropriate adjustment responses if the GHG reduction targets are to be met. Currently, climate mitigation policies are carbon "blinkers" and are, sometimes, contradictory. Policy support for local implementation of GHG emission mitigation practices in the rural land use sector relies on Farming for a Better Climate mechanism, which only promotes voluntary GHG emission reduction in rural land uses. In addition, farmers/land owners which are not yet rewarded for carbon sequestration, view themselves as a 'special case' whose main function is to produce food and not to mitigate climate change.

Understanding the basic attitudes, motivations and objectives is essential to explain divergences in farmers' engagement with climate change mitigation activities. Government should intervene more strongly, offering both rewards and penalties, but policies have to be flexible to allow differentiation, and mitigation measures have to be integrated with other land use sector mechanisms. Without this, EU, national and regional climate change mitigation targets, are not likely to be achieved.

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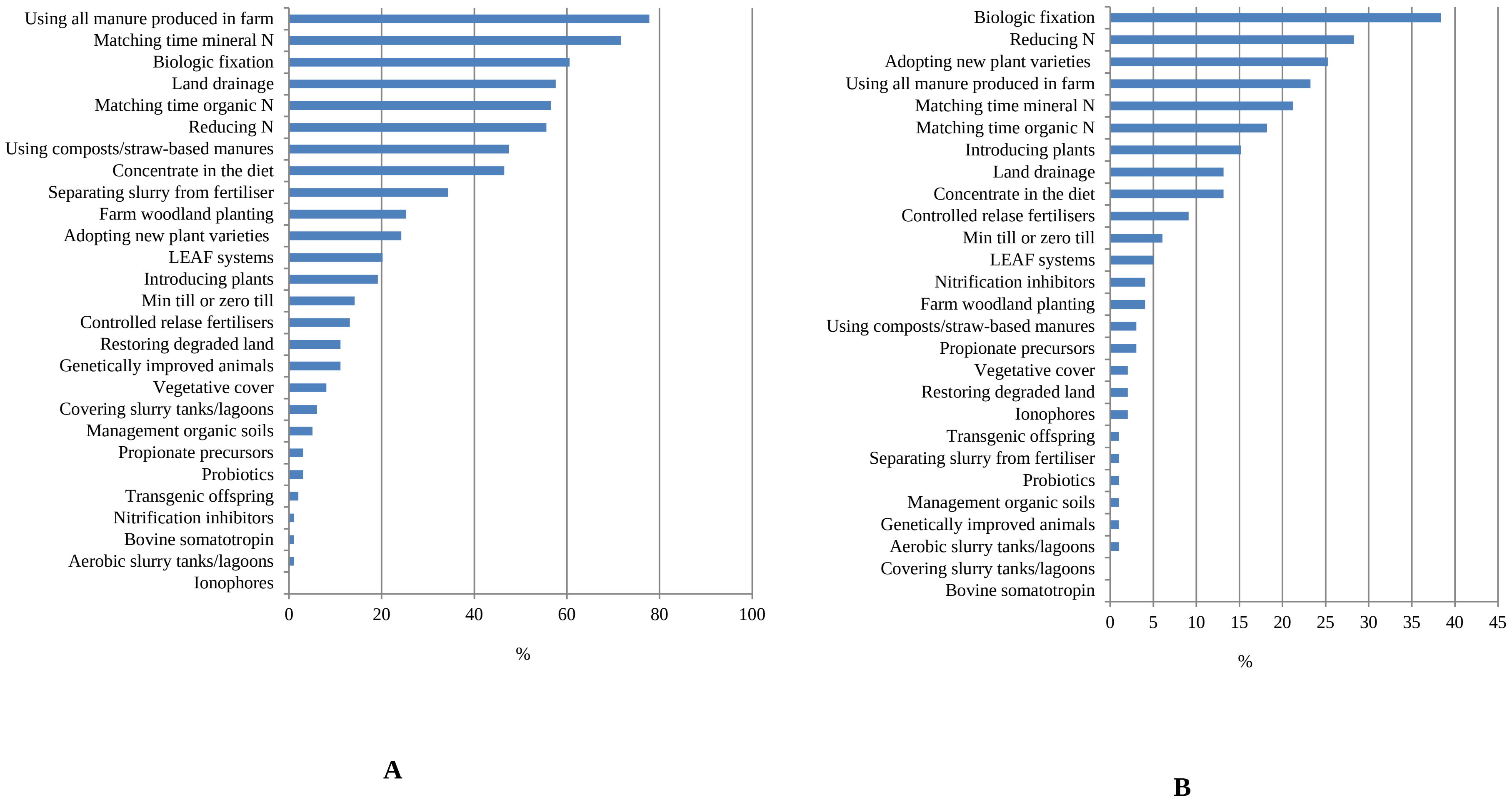

Figure 1 Current (A) and future mitigation (B) practices adopted by farmers who answered the questionnaires at the livestock marts in the North East Scotland

Table 1: Framework of barriers, enablers and policy mechanisms to the implementation of GHG emission mitigation practices in North East Scotland

Barriers	**Rationale**
Transaction costs	Farmers will not adopt unprofitable mitigation practices in the absence of incentives (Smith & Olesen, 2010).
Financial constraints	Financial constraints carry large investment costs and obtaining finance for this may be difficult, if the revenue obtained is uncertain (Smith & Olesen, 2010).
Physical-environmental constraints	Lack of capacity to change due to certain farm environments, size and type of farm, farmer demographics, productive capacity of land or climate. (Dandy, 2012; Hallam, 2012).
Lack of information and education	Some GHG mitigation options are not implemented due to the lack of knowledge and skill at the local farm level (Smith & Olesen, 2012).
Interference with other regulations	There is considerable regulation of land-use, which creates wide-ranging and sometimes complex 'rules' (Dandy, 2012). The implementation of mitigation options may interfere with other regulations (Smith & Olesen, 2010).
Personal interests and values	Land managers' attitudes, values and beliefs have an impact on farmers' behaviour and consequently farm management (Hallam et al., 2012).
Community and Society	Land-managers live and work within wider communities and societies which impact upon their decision-making in a variety of ways (Dandy, 2012; Hallam, 2012).
Enablers	**Rationale**
Operational costs	When GHG mitigation practices reduce costs of production or contribute to increase the profit.
Market	This is based on the notion that market characteristics and conditions affect land-manager decision making. This concerns price & margin of the product, and market scale, infrastructure and security (Dandy, 2012).
Incentives	A variety of incentives are offered across the land management sector for example: grants, cost shares, preferential, finance schemes, tax relief, or payment schemes (Dandy, 2012).
Operations	The industry capacity in terms of skills, labour and hardware availability and the practicalities of work. Where a particular practice is thought to be difficult or awkward to implement managers might be disinclined to choose it (Dandy, 2012).
Resource	The perceived availability of the resource and assessment of what type and quality of products is likely to flow from particular land areas and land management practices (Dandy, 2012).
Physical-environmental factors	Capacity to change due to certain farm characteristics, size and type of farm, farmer demographics, productive capacity of land or climate suitability (Dandy, 2015; Hallam, 2012).
Personal interests and values	Land managers' attitudes, values and beliefs have an impact on farmers' behaviour and consequently on farm management (Hallam et al., 2012).
Community and society	Land-managers live and work within wider communities and societies which impact upon their decision-making in a variety of ways (Dandy, 2012; Hallam, 2012).
Regulation	Regulation, that is the formal aspects of governance, establishes many of the 'rules' which set the boundaries of land managers' decision-making. Regulatory system can have a particularly strong impact upon decisions to change land-management (Dandy, 2012).
Policy mechanisms suggested to promote the uptake	**Rationale**

Regulation	Placing restrictions on what farmers are legally allowed to do and prohibit undesirable management practices (Hallam et al., 2012).
Economic incentives	A variety of incentives are offered across the land management sector for example: grants, cost shares, preferential, finance schemes, tax relief, or payment schemes (Dandy, 2012).
Market-led and 'voluntary' approaches	Promoting environmentally beneficial management practices to encourage higher standards of environmental behaviours among farmers (Hallam et al., 2012). For example: Farming for a Better Climate (FFBC).
Education/information provision	Raising awareness of climate change issues, what can be done to undertake climate change mitigation and why this can be beneficial to land managers (Hallam et al., 2012).

Table 2: Barriers to the implementation of mitigation practices in North East Scotland

Mitigation practices	**Barriers**
Precision farming	**Financial constraint**s: There is an extra cost. An annual charge to pay for the connection (FG). **Physical-Environmental constraints:** Is not cost-effective in small scale farms (FG). **Lack of information and education:** Complex software installed in the machinery (PW).
Biological fixation with clover	**Transaction costs**: Lack of incentives (PW). **Physical-Environmental constraints:** It only works at certain temperatures (FG); Heavy stock dealers cannot reduce fertiliser application (FG). **Lack of information and education:** Lack of awareness of the benefits (PW); It may cause sheep bloating (PW); Difficult to manage (PW); It is difficult to establish clover (FG). **Community and society:** Historically is seen as an "eccentric/not for business" practice, associated with organic production (PW).
Genetically improved animals	**Physical-Environmental constraints:** Long-term project which may take up to 10 years to achieve (PW). **Lack of information and education:** Mechanisms not well understood: risks (PW). **Community and society:** Existing breeders are against Estimated Breeding Values (EBVs) and against change and costs (PW).
Mixed farming systems	**Financial constraints:** Not great margins for farmers (PW); Labour intensive (PW).
Peatland restoration	**Financial constraints** Cost (PW); **Lack of information and education:** Lack of knowledge about the timescale and where to restore (PW).
Woodland planting (including hedgerows; agro-forestry)	**Physical-Environmental constraints:** Agro-forestry: Labour intensive (PW); Potential soil carbon emissions (PW); Productivity of farm woodland tends to be neglected (PW). **Personal interests and values:** Farmers do not want to be foresters (PW); It might look like an imposition to tell land owners/farmers where to plant trees (PW). Negative attitude: "*it is a waste*" (FG).
Minimum tillage/zero tillage	**Financial constraints:** Does not save much fuel (FG). **Physical-Environmental constraints:** Weather dependent (FG); In some cases it affects yields, in others do not (FG); Some years are favourable some are not (FG).
Reduce nitrogen application	**Physical-Environmental constraints:** Every year is different. It is variable according to the years (FG). **Personal interests and values:** Negative attitude: *"I still carry on. I have to keep my*

	production" (FG).
Permanent grassland	**Financial constraints:** It is not economically advantageous (FG). **Physical-Environmental constraints:** The quality of the grass is not satisfactory (FG); 5-7 year grasses are more productive than permanent grass (FG); After 7 years the quality decreases (FG). **Personal interests and values:** Negative attitude: "*It does not really work for me.*"(FG).
Matching the time of organic fertiliser application with the time the crop take the most out of it	**Physical-Environmental constraints:** Depends on the weather (FG); Seasons are very variable in NE Scotland (FG); Official dates for spreading manure do not ensure the practice is implemented when the weather conditions are right (FG).
Incorporating residues in the soils	**Financial constraints:** Extra-fuel consumption (straw has to be chopped) (FG). The straw has high market value (FG).
Feeding ionophores/probiotics to livestock	**Community and society:** General public is against it (FG); Veterinaries are against it (FG).
Renewable energy	**Transaction costs**: It may take more than a year to pass an application (FG). **Interference with other regulations:** Different requirements for different sub-regions within Aberdeenshire (FG). Anaerobic digestion: It is forbidden to apply the digested product in the land (FG). **Community and society:** Planners do not like to see turbines on the top of the hill (FG); Environmental health carers do not like renewable energy (FG).

Note: PW- Scientists and stakeholders at participatory workshops; FG- Farmers at focus groups; FQ- Farmers questionnaire.

Table 3: Enablers to the implementation of mitigation practices in North East Scotland

Mitigation practices	Enablers
Precision farming	**Operational costs**: Save fuel (FG); Save fertiliser (FG). **Resource:** It promotes the efficient use of resources without penalizing production (PW); Much better return on nitrogen (PW). **Physical-environmental:** Higher yields of spring cereals (PW).
Biological fixation with clover	**Operational costs:** No additional costs (FQ); It replaces artificial nitrogen (PW). **Operations**: Easiness of implementation (FQ); Local experience (PW). **Physical-environmental:** Significant potential due to substantial acreage in North East Scotland (PW); To increase productivity (FQ); Grassland yield is not affected (FQ); Most farmers in North East Scotland could produce around 90% of the current grass growth with clover (PW). **Personal interests and values:** Positive attitude: "*We have been doing this for years*"; "*You can use clover. A small amount of it.*"; "*Definitely a plus*" (FG)**.**
Genetically improved animals	**Operational costs:** To increase profit (FQ). **Operations:** Increase efficiency (PW); Higher efficiency (FG). **Physical-environmental:** Increase fertility (PW). **Personal interests and values:** Positive attitude: "*We have been doing it for years.*" (FG)

Mixed farming systems	**Operational costs:** Economies of scale (PW). **Operations:** Increase efficiency (PW). **Resource:** Internalises nitrogen use (PW).
Peatland restoration	**Physical-environmental:** There is a large area of abandoned peatland in the North East Scotland that can be restored (PW); Practice with high technical potential because it is a good store of carbon (PW).
Woodland planting (including hedgerows; agro-forestry)	**Incentives:** Availability of grants (FQ); **"***Only because I get paid for it to be honest*" (FG). **Resource:** Trees provide wood energy, which can displace fossil fuels (PW); More timber can be used in construction and to store carbon for a longer period (PW); Fuel security (FQ). **Physical-environmental:** Trees can sequester CO_2 (PW); Farms can become carbon neutral (PW); Hedgerows: Improve the microclimate of the field (PW); It matches farm characteristics (FQ). **Community and society:** Agro-forestry: part of Scottish heritage (PW); Aesthetic reasons (FQ).
Minimum tillage/zero tillage	**Operational costs:** Increase profit margin (FG); Save some fuel (FG & FQ**)**; Reduce costs (FG). **Operations:** Increases the speed of operations (FG). **Physical-environmental:** Reduces soil compaction (FG).
Reduce nitrogen application	**Operational costs**: To reduce costs (FQ); High fertiliser prices (FQ); *"People never wasted it"* (FG). **Operations:** To stop leaching to the ground (FQ). **Regulation:** Nitrate Vulnerable Zone regulations (FG); Compulsory in organic farms (FQ).
Using the manure produced in the farm	**Operations:** To minimise nutrient loss (FQ); Easiness of implementation (FQ). **Personal interests and values:** Positive attitude: "*We now have dates when we can spread and we cannot spread. But these dates mean nothing to us*" (FG); Already doing it (FQ). **Regulation:** Nitrate Vulnerable Zone regulations (FG).
Matching the time of organic fertiliser application with the time the crop take the most out of it	**Operational costs**: No additional costs (FQ). **Operations:** Livestock becomes fat earlier (FG). **Physical-environmental:** To mitigate climate change (FQ); It matches farm characteristics (FQ). **Personal interests and values:** Positive attitude: *"If I stand still* (do not increase concentrate) *someone is going to overtake me."*; *"I always increased"*. (FG).
Incorporating residues in the soils	**Operational costs:** Increases soil carbon (FG).
Feeding ionophores/probiotics to livestock	**Operational costs:** Improves profitability (FG). **Physical-environmental:** GHG emission reduction by 10-12%. (FG). **Personal interests & values:** Positive attitude: *"Definitely happy to adopt"* (FG).
Land drainage	**Operational costs:** To increase profit (FQ). **Physical-environmental:** To increase production (FQ).
Renewable energy	**Operational costs:** To increase profit (FQ). **Market:** To generate power to sell to the grid (FQ). **Operations:** To handle manure better (Small-scale anaerobic digester) (FQ). **Operations**: To handle manure better (Small-scale anaerobic digester) (FQ). **Physical-environmental:** Wind turbines can be implemented in the poorest ground (FG); **"***It matches farm characteristics*" (FG).**Personal interests and values:** Positive attitude: "*If every farmer could have one (wind turbine) they would be delighted"* (FG).
Adopting new plant varieties that can produce the same yields using less nitrogen	**Operational costs:** No additional costs (FQ); To reduce costs (FQ). **Operations**: Easiness of implementation (FQ); To save fertiliser (FQ).
Matching the time the crop will make the most use of the mineral fertiliser	**Operational costs:** Better value for money (FQ). **Operations**: Efficiency (FQ).
Introduce plant species that take up more nitrogen from the system	**Operational costs:** To reduce costs (FQ). **Operations:** To save N fertiliser (FQ). Easiness of implementation (FQ).
Using controlled release fertilisers	**Operational costs:** To save money (FQ). **Operations:** Less time and labour (FQ); It works longer (FQ). **Physical-environmental**: Better soil husbandry (FQ).
LEAF (Linking Environment	**Operational costs:** To reduce fertiliser costs (FQ). **Operations:** Easiness of implementation (FQ); To save fuel (FQ).

and Farming Systems)	
Adopting vegetative cover between crops	**Operational costs:** Easiness of implementation (FQ).
Restore degraded land	**Operational costs:** To increase profit (FQ).
Separating slurry from fertiliser	**Operational costs:** To reduce costs (FQ).
Adopting enhanced management of organic soils	**Physical-environmental**: It matches farm characteristics (FQ).
Cover slurry tanks	**Regulation:** Compulsory (FQ).

Note: PW- Scientists and stakeholders at participatory workshops; FG- Farmers at focus groups; FQ- Farmers questionnaire.

Table 4 Mechanisms suggested by workshop participants to promote the uptake of mitigation practices

Mitigation practices	Regulation	Economic incentives	Market-led and 'voluntary' approaches	Education/information provision
Precision farming	-	Subsidies for soil analysis.	Machinery rings.	Make it simpler for farmers; Training.
Biological fixation with clover	-	Incentives.	Co-operative approach.	Demonstration; Farm visits; Monitoring farms; Spreading information.
Genetically improved animals	Improve growth rates/productivity; Decreasing mortality.	Cutting input costs.	Adoption of EBVs, of genetic modified animals (GM), and of certain traits.	Knowledge transfer; Monitoring farms; Demonstration.
Mixed farming systems	-	-	-	-
Peatland restoration	-	Financial incentives; Market-based instruments.	-	-
Woodland planting (including hedgerows; agro-forestry).	-	Forestry grants.	-	-

Appendix 1 Farmers questionnaire

Mitigation Measures in Agriculture in North East Scotland

This questionnaire is designed to gather information for a PhD research project being carried out in conjunction with the **University of Aberdeen** and **The James Hutton Institute**. The aim is to identify **current and potential uptake of mitigation measures in agriculture without reducing the level of output**. As you may know the Scottish Government has set a **42% greenhouse gas emission reduction target** for the rural land use sector by 2020.

This questionnaire will be treated ***totally confidentially*** *and none of the information provided will be associated to you or your farm business.*

Question 1

Please indicate your postcode *(please note your postcode will only be used for geographical analysis and not used to identify individual farming businesses)*

Postcode:

Question 2

What type of farm (primary production) do you run? *(please indicate with a cross in the appropriate box)*

Cereals	☐	Dairy	☐
General cropping	☐	Cattle and Sheep (LFA)	☐
Horticulture	☐	Cattle and Sheep (Lowlands)	☐
Specialist Pigs	☐	Mixed	☐
Specialist Poultry	☐	Other - *please describe:*	

Question 3

What is the approximate size of your farm?

Enclosed land ____ *hectares*

Rough grazing ____ *hectares*

Question 4

Did you ever use a carbon footprint calculator to estimate greenhouse gas emissions for your farm?

NO ☐ YES ☐ If yes enter which calculator:

Question 5

a) In **column A** of the table overleaf, please indicate with an **X** any practice(s) you currently carry out at your farm.

b) In **column B** of the table overleaf, please indicate with an **X** the top three practices, including any current practices, you would implement if you had to reduce the greenhouse gas emissions of your farm by 20% in 2020.

c) In **column C** of the table overleaf, please state the main reason for your choice.