Interim report on greenhouse gas emissions from Irish agriculture:

Teagasc submission made in response to the discussion document on the potential for Greenhouse Gas (GHG) mitigation within the Agriculture and Forestry sector.

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1 Key Messages

1. ***Agricultural greenhouse gas emissions in the context of Food Harvest 2020***
   The initial dairy expansion up to 2020 will 'fill the headroom' in production that has been created by 30 years of production constraints in the quota environment. It is likely that the Food Harvest 2020 will be achieved through a combination of changing animal demography and further increases in efficiency, rather than through an increase in total bovine numbers. As a result, it is technically feasible to achieve Food Harvest 2020 targets while flatlining greenhouse gas emissions.

2. ***Agricultural greenhouse gas emissions in the context of plans for a 2025 Agri-Food Strategy***
   However, a potential post-2020 strategy of further expansion, additional to Food Harvest 2020, is likely to be much more substantially based on a direct increase in dairy cow numbers. While such a further expansion could still result in a continued reduction of the emission intensity of Irish produce, it may prove difficult to achieve this further increase in dairy cow numbers without an absolute increase in national agricultural GHG emissions.

3. ***Research is delivering new cost-beneficial mitigation options for agriculture***
   It is envisaged that Teagasc will develop and publish a second version of the agricultural MACC for Irish agriculture in 2016, with a time horizon of 2025. On-going research into new technologies and measurement of GHG mitigation has identified a number of additional mitigation options which will be considered in the development of this second iteration of the MACC. These include the use of sexed semen, use of novel low-emission fertiliser mixes, inclusion of animal health programmes and enhanced carbon sequestration.

4. ***Progress in agricultural mitigation is likely to be higher than can be reported in the national inventories***
   It remains challenging to capture the efficacy of mitigation measures in the national agricultural inventory. While inventories can account for measures that reduce the amount of an activity (e.g. the amount of fertiliser), they cannot account for qualitative changes (e.g. fertiliser type). As a result, progress in agricultural mitigation is likely to be higher than can be reported in the national inventories.

5. ***The Teagasc National Farm Survey is measuring the 'carbon footprint' of Irish produce***
   The emissions intensity ("carbon footprint") of Irish livestock produce compares favourably with other EU members states and indeed other argo-climatic zones and production systems worldwide. In this context, it is imperative that Ireland systematically collects data on farm level GHG emissions, using methodologies of data collection and computation that stand up to scientific scrutiny. Therefore, the Teagasc National Farm Survey (NFS) has been extended to estimate GHG emissions associated with each farm enterprise using both IPCC coefficients and LCA conventions to produce an estimate of total emissions per farm, providing a distribution profile of national agricultural GHG emissions. This is part of a development of the NFS to quantify sustainability as a composite of economic, social, environmental and innovation parameters.

6. ***Teagasc and DAFM are leading the global partnership on methodologies for carbon-footprinting***
   In addition, DAFM and Teagasc are currently chairing the Livestock Environmental Assessment and Performance (LEAP) Partnership of the United Nations Food and Agriculture Organisation (FAO), which is developing harmonised global guidelines for the computation of emission intensities for livestock supply chains.

7. ***Mitigation based on efficiency is currently excluded from supports under agri-environmental schemes***
   Mitigation at farm level is the key challenge facing the sector over the next 10 years, as full uptake of the cost-beneficial and cost-effective measures in the MACC is unlikely to materialise in the absence of targeted incentivisation measures. A guiding principle of EU funded schemes is that the calculation of premia is based on cost incurred and income foregone by the farmer for participating in the agri-environmental measure. This implies that the efficiency measures identified in the MACC curve are currently excluded from supports under agri-environmental schemes. Without a very fundamental change

in the principles governing agri-environmental schemes, potential future schemes may have little prospect of further incentivising adoption of low-carbon practices.

8. ***Existing knowledge transfer programmes***
Over the last five years the Department of Agriculture Food and the Marine has introduced a series of innovative technology transfer support measures that include the Dairy Expansion Programme (DEP), the Beef Technology Adoption Programme (BTAP) and the Sheep Technology Adoption Programme (STAP) and that were consistent with the MACC. An evaluation of the DEP found that dairy discussion groups are an effective mechanism in the delivery of advice; are impacting on management and efficiency; and are generally delivering to the expectations of farmers.

9. ***New knowledge transfer programmes***
Based on the success of these programmes, the Department of Agriculture Food and the Marine have now built a further series of Knowledge Transfer measures, as part of its 2014-2020 rural development programme (RDP). The inclusion of the Teagasc – Bord Bia Farm Carbon Navigator as a specific measure in these schemes is aimed at improving farmer awareness and performance in relation to GHG mitigation and will provide significant support for the improvement of the carbon efficiency of Irish agricultural output. The further upscaling of these and similar Knowledge Transfer activities, as recommended by the Environmental Analysis of Food Harvest 2020 (Farrelly, 2014), will require significant and continued funding and resources.

10. ***EU policy for 2030: towards integrated land management***
The European Council Decision of 23-24 October 2014 on the proposed EU Climate and Energy Package for 2030 endorsed a radically new approach to the role of agriculture in mitigating climate change. This decision opens the door to a new approach towards minimising the impact of agriculture on the global climate, i.e. an approach that is not merely based on reducing direct emissions, but also acknowledges and incentivises the positive effects of agriculture on reducing atmospheric greenhouse gas concentrations, for example through sequestration of carbon dioxide. In response, Teagasc is now assessing approaches to maximising the carbon sink potential of land, protect the maintenance of carbon reservoirs and minimise carbon losses from land.

11. ***The afforestation rates proposed in the new afforestation programme are insufficient to substantially increase offsetting of agricultural emissions.***
Government policy has reiterated its commitment to expand the productive forest area to approximately 1.25 million ha or 18% of the land area by 2046. This will require an afforestation target of 16,000 hectares per annum. The current programme plans to increase forestry planting to approximately 7,300 ha annually for the next 6 year, i.e. less than half the planting rate required to meet the target of 18% forest area by 2046. The proposed planting rate of 7,300 ha per annum is insufficient to increase offsetting of agricultural emissions. In fact, it is below the rate required to simply maintain offsetting level beyond 2030, thus making future planting targets even more onerous. Achieving the ambition for 2046 will necessitate an immediate additional and concerted effort, combining incentivisation with effective support and targeting for forest planting. It may be necessary to reconsider certain land types that have been excluded from the afforestation programme due to site characteristics but may have the potential to produce commercial timber crops and sequester carbon dioxide.

12. ***Expansion of afforestation may need to be balanced with other environmental objectives***
In many cases, conservation constraints may limit or preclude forestry expansion or land use change. Where competing environmental objectives exist, there may be merit in considering strategies that optimise the totality of environmental benefits. It is important that the multiple objectives of forestry, such as raw material provision, diversification, water protection, biodiversity enhancement and recreation are evaluated in addition to carbon sequestration and that the relative importance of these objectives are agreed.

2 Context

2.1 Purpose of this document

Teagasc is pleased to avail of the opportunity to make a submission to the discussion document on the potential for Greenhouse Gas (GHG) mitigation within the Agriculture and Forestry sector, published by the Department of Agriculture, Food and the Marine (DAFM).

This current submission builds on the previous three reports by the Teagasc Working Group on Greenhouse Gas Emissions, which:

- Described the state-of-the-art, the challenges and opportunities for reducing greenhouse gas emissions from agriculture (Teagasc, 2011)
- Quantified the total mitigation potential of Irish agriculture by 2020 in the form of a Marginal Abatement Cost Curve (MACC) (Teagasc, 2012)
- Assessed additional long-term pathways to a low-carbon agricultural sector in a post-Kyoto environment (Teagasc, 2013)

Since publication of the last report, the context of discussions on agriculture and greenhouse gas emissions has continued to evolve. Specifically, we have witnessed the following three developments:

1. The European Council Decision of 23/24 October 2014 (European Council, 2014) has changed the European policy environment on approaches to mitigating agricultural greenhouse gas emissions;
2. At national level, discussions have commenced on formulating a successor to the Food Harvest 2020 strategy, i.e. a Agri-Food 2025 strategy;
3. Science and knowledge transfer activities in relation to agricultural greenhouse gas emissions have continued to evolve and are delivering further opportunities for a low-carbon agricultural sector.

This submission is an interim report from the Working Group and provides updates on these developments in policy, research and knowledge transfer.

2.2 Agricultural GHG emissions in the context of the Food Harvest 2020 Strategy

Food Harvest 2020 is the agri-food industry's strategy for a substantial increase in the volume and value of output from the sector, with a particular focus on a 50% expansion in dairy volume output by 2020 on removal of the dairy quota regime, in addition to targets for value and exports for all other sectors including beef, sheep, tillage and the marine. The potential impact of the achievement of Food Harvest 2020 targets on GHG emissions has been the subject of much speculation and study in recent years.

Teagasc modelled a range of scenarios that took into consideration the on-going increases in production efficiency, the efficiencies achieved through the ending of the Milk Quota Regime and the likely displacement effect of an increased dairy cow herd on the beef cow herd and predicted that achievement of Food Harvest 2020 was likely to lead to an increase in annual agricultural emissions of the order of 1.2 Mt CO_2e or *c.* 6% compared to average emissions during the 2008-2012 first Kyoto commitment period, or an increase of 0.2 Mt CO_2e or 1% compared to the EU reference year of 2005 (Teagasc, 2012). It was also estimated that the accelerated achievement of practice changes, as outlined in the MACC, result in a possibility of achieving a flatlining of GHG emissions relative to 2010 levels.

The role of Animal Demography

The possibility of sustained increases in dairy output while 'flatlining emissions' is to a large extent predicated on changes that are projected to take place in the structure, or demography, of the Irish bovine herd. Changes in bovine population are closely linked to agricultural GHG emissions. For example , the total Irish cattle population increased in size in 2013 and was a contributing factor to the increase in Irish greenhouse gas emissions in that year. This increase in the cattle population was as a direct result of historically lower exports of young animals, rather than an increase in the number of calves being produced by the breeding herd of dairy and suckler cows. Cattle slaughtering in Ireland rose significantly in 2014 in response to the increased number of animals that had reached finishing age. Consequently, at the end of 2014, the upward trend in the total Irish bovine population observed in 2013, had begun to reverse.

The dairy herd is projected to increase

Future developments in Irish agricultural GHG emissions will be a function of the size of the bovine sector which in turn will be influenced by the removal of the milk quota system in 2015. On a per hectare basis, milk production remains by some distance the most profitable mainstream agricultural activity in Ireland. While individual dairy farms in Ireland have increased in size over time, this has only been possible via a reduction in the total number of farms, given the presence of the milk quota system. Additionally, the number of dairy cows in Ireland has been in decline for much of the period in which the milk quota system has been in place. This is due to improvements in dairy cow productivity (higher milk yields per cow), which allowed the national milk quota to be filled with a smaller national dairy cow herd.

The historic downward trend in dairy cow numbers has been reversed over the last 4 years, with an increase in the Irish dairy cow population by 12% (CSO December enumeration) since 2010. This increase in dairy cow numbers reflects investment decisions made by dairy farms in response to the annual increases in the milk quota that occurred in the run-up to its abolition, and its impending abolition as set out in the CAP. Over the next ten years, a considerable expansion in the number of dairy cows in Ireland is envisaged, reflecting the sector's high level of profitability. Existing dairy farms in Ireland remain relatively unspecialised and this will allow for an increase in dairy cow numbers even in the absence of new entrants to the dairy system. Additionally, it can be expected that there will be some conversion of land from others systems to dairy farming. The capital needs and resultant repayment requirements associated with conversion will mean that new entrants to the dairy sector will typically be required to operate at a scale which is larger than the average size of dairy operation in Ireland at present. This scale requirement will be a limiting factor in terms of the number of new entrants to the dairy sector in the short term. Smaller non-dairy farms will be unsuited to conversion to dairying on economic grounds.

The projected response of the beef sector to the increase in dairy calves

The expansion of the dairy herd will result in an increased number of dairy calves. Some of these will be retained as replacements for the dairy herd. The number of replacements required will increase in order to augment the growing dairy cow herd. Nevertheless, there will be an increase in the number of calves of dairy origin which will either need to be raised to adult slaughter age for be ef, exported as young animals or processed by some other means. Other things being equal, this would result in a significant increase in the Irish cattle population.

However, the income generated in the other side of the cattle breeding population, the sucker herd, is very low on both a per hectare and on a per farm basis. In suckler farming, small farm size is compounded by inferior land and climatic conditions which have an adverse impact on direct production costs, the low value of farm output, low levels of technology adoption, and a high dependency on support payments, which are the principal source of income in the sector. As a result, the size of the sucker herd has declined more than 8 percent in the two year period to the end of 2014. Projections are that incomes of the beef sector will continue to remain low and that the suckler herd will continue to contract over the next decade. Consequently, the number of sucker calves produced is projected to decline. The contraction in the suckler herd and its associated progeny should offset to some extent the increase in the dairy cow herd over the coming decade. Taken together the expansion in the dairy herd and the contraction in the beef herd is projected to result in a relatively stable total bovine population in Ireland.

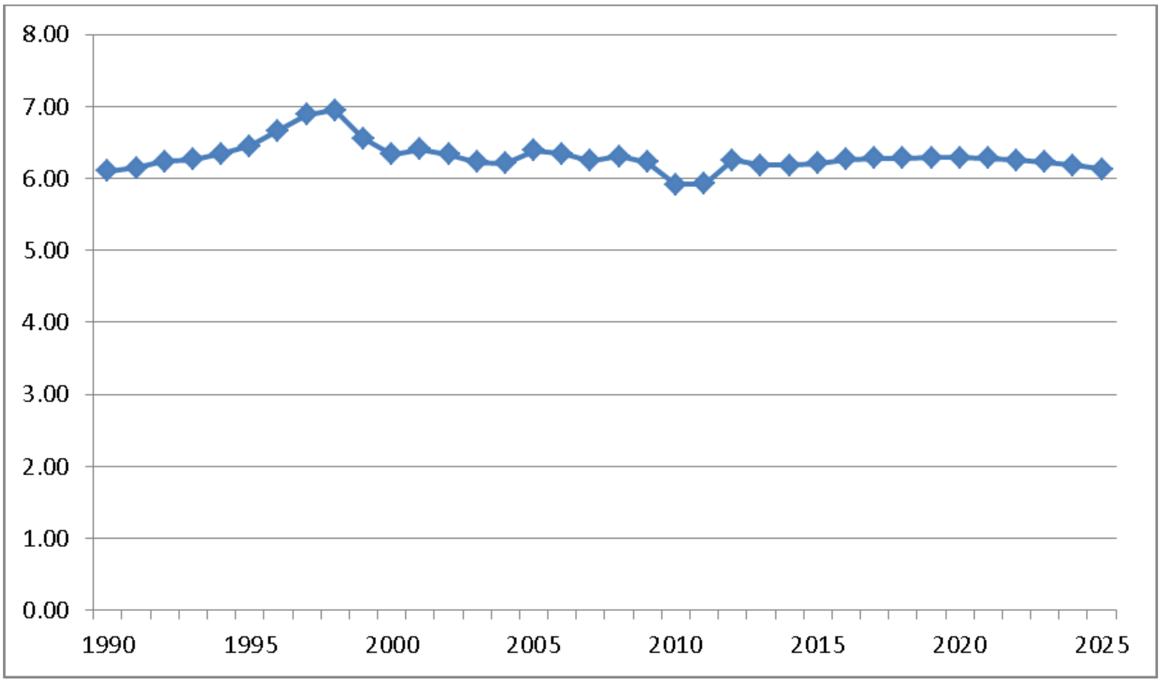


Figure 1: Historical and Projected Total Irish Bovine Population (Source: Donnellan and Hanrahan, 2014)

2.3 Beyond 2020: emissions in the context of a 2025 Agri-Food Strategy

A scenario of substantial further increase in dairy production beyond 2020, however, could significantly impact on the profile of the total cattle population and on the contribution to agricultural GHG emissions. The initial expansion of dairy output in the 2015-2020 period, as envisaged in the FH2020 strategy, will be based on increases in animal numbers, the removal of inefficiencies and restrictions at farm level directly related to the quota system (e.g. holding back on output to reduce superlevy, holding down input levels and the use of milk to feed calves) and on on-going efficiency improvements. Put simply: the initial dairy expansion up to 2020 will 'fill the headroom' in production that has been created by 30 years of production constraints in the quota environment.

However, a potential post-2020 strategy of further expansion, additional to Food Harvest 2020, is likely to be much more substantially based on a direct increase in dairy cow numbers. While such a further expansion could still result in a continued reduction of the emission intensity of Irish produce, it may prove difficult to achieve this further increase in dairy cow numbers without an absolute increase in national agricultural GHG emissions. Given that, on average, the carbon footprint of dairy beef systems are almost 50% lower than suckler systems, it will become essential to maximise the value added of dairy beef systems.

3 Agriculture - Scientific Developments

In this Section, we provide an update on the developments in research on agricultural GHG emissions, specifically updates on:

- the development of MACCs for agriculture (Section 3.1)
- the development of emission intensity metrics (carbon footprints) of Irish produce (Section 3.2)
- the computation methodologies and datasets for the National Agricultural Inventories (Section 3.3)

3.1 Updating the Marginal Abatement Cost Curve for Agriculture (MACC)

The MACC for Irish Agriculture (Teagasc, 2012) is based on extensive research programmes conducted by Teagasc and national and international research partners over the last decade. It is important to note that a MACC cannot remain constant: on publication in 2012 it was pointed out that the report should be interpreted as the first outcome of an iterative process and that developments in the science of GHG abatement, market conditions, socio-economic conditions and agronomic conditions faced by Irish agriculture would continue to shape the MACC into the future. It is envisaged that Teagasc will develop and publish a second version of the agricultural MACC in 2016. In this current submission, it is appropriate to highlight some of the key issues that are likely to emerge in this second iteration of the MACC.

Developments in MACC methodology: towards disaggregated MACCs

The 2012 MACC for Irish Agriculture presented the total abatement potential and associated cost-benefits of a number of mitigation options. These underlying data were based on aggregated farm data. However, every farm is different in terms of climatic conditions, production costs, enterprise mix and level of efficiency. On top of this farmers differ greatly in terms of their ability to adopt new technology and implement practice change and in terms of their understanding of and attitude towards achieving GHG mitigation on their farms. For example, some mitigation options require a level of managerial ability not present across all farms. All these factors together result in significant variation in farm level mitigation potential and costs associated with that mitigation. As a result of these differences, each farm will effectively have a unique MACC with different mitigation costs and potential.

The Teagasc National Farm Survey (NFS) has now begun to provide farm-level data necessary to construct farm-level MACCs. The Teagasc NFS also provides the data necessary to understand individual farm and farmer characteristics that impact on a farmer's ability to realise their mitigation potential. Teagasc is conducting a number of research projects aimed at better understanding the barriers to adoption of GHG mitigation options. This research will provide insight into developing a suite of support measures necessary to realise the bio-physical mitigation potential.

Developments in MACC methodology: new options for consideration

The MACC for Irish agriculture only includes mitigation options that have a scientifically verified potential to reduce emissions and that have the capacity to be implemented at farm level. On-going research into new technologies and measurement of GHG mitigation has in the meantime identified a number of additional mitigation options which will be considered in the development of the second iteration of the MACC for Irish agriculture. These include:

1) The use of sexed semen: this technology has the capacity to reduce the number of dairy cows bred to dairy breeds and thereby increase the utilisation of beef sires. This can improve the carbon efficiency of Irish beef by improving average animal performance and increasing the proportion of beef output coming from the dairy herd (Figure 2):

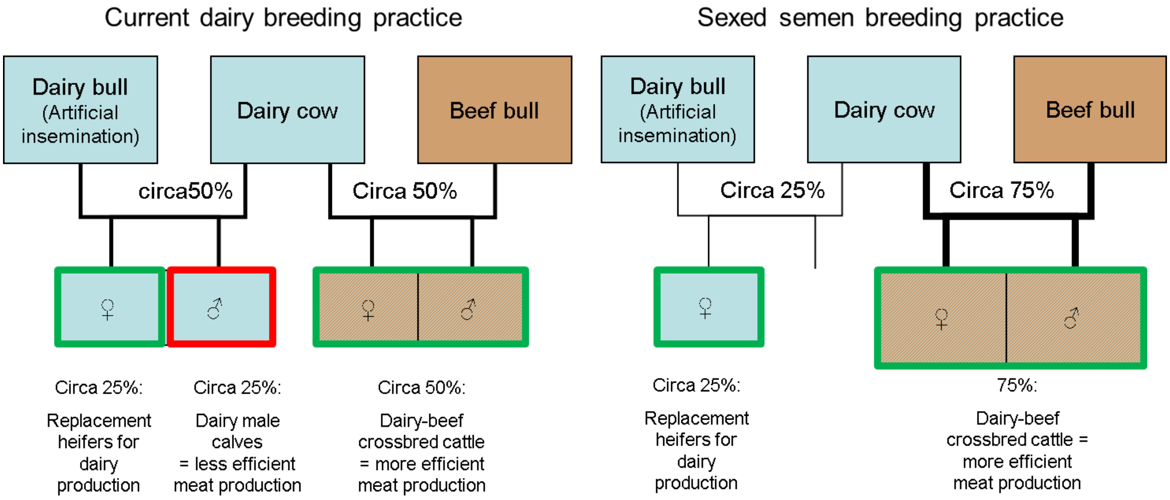


Figure 2: The use of sexed semen improves the efficiency of beef production from dairy offspring and hence reduces the GHG emission intensity of both dairy and beef produce.

2) Increased use of novel fertiliser mixes: The use of urea in combination with effective nitrogen stabiliser additives has the capacity to make significant and cost-effective reductions in emissions from grassland and tillage crops.
3) Additional improvements in animal health status of the Irish Dairy and Beef herd, supported through the implementation of effective preventive health initiatives and improvements in veterinary care, have the capacity to improve herd fertility and output efficiency and reduce the carbon efficiency of dairy and beef production.
4) Grassland sequestration: Irish pastures have the capacity to sequester carbon. Research into the extent and sustainability of this sequestration is on-going and is focusing on the management practices that may encourage enhanced sequestration

Until the potential of these new measures has been fully analysed, it is difficult to anticipate the abatement potential or cost-effectiveness, of each of these mitigation options. However, in 2014 we made *preliminary and indicative* estimates of the 2030 abatement potential for agricultural greenhouse gas emissions, in which we estimated that the combined marginal abatement potential some of these aforementioned new options is likely to amount to 0.5 to 1.0 Mt CO_2e per year.

3.2 Tracking progress on farm level emissions indicators using Teagasc NFS data

The emission intensities of Irish livestock produce compare favourably internationally

In previous reports, Teagasc has highlighted international studies that found that the emissions intensity ("carbon footprint") of Irish livestock produce compares favourably with other EU members states (Leip *et al.*, 2013) and indeed other agro-climatic zones and production systems worldwide

(FAO, 2008). These findings have been instrumental in informing and supporting science (e.g. Schulte *et al*., 2015), policy formation (e.g. DAFM sectoral roadmap, 2015) and marketing initiatives (e.g. Bord Bia's Origin Green).

Harmonising scientific approaches to computing emission intensities

It is imperative that we systematically collect data on farm level GHG emissions, using methodologies of data collection and computation that stand up to scientific scrutiny. DAFM and Teagasc are currently chairing the Livestock Environmental Assessment and Performance (LEAP) Partnership of the United Nations Food and Agriculture Organisation (FAO), which is developing harmonised guidelines for the computation of emission intensities for livestock supply chain, as well as other environmental indicators such as Nutrient Use Efficiency. Draft guidelines for large ruminants will be released at the General Annual meeting of LEAP in Rome on 24 April 2015. For details, see: http://www.fao.org/partnerships/leap/en/

Systematic data collection using the Teagasc National Farm Survey

The computation of emission intensities requires systematic and objective data collection on farm activities. Therefore, the Teagasc National Farm Survey (NFS) has been extended to estimate GHG emissions associated with each farm enterprise using IPCC coefficients and conventions to produce an estimate of total emissions per farm for the 950 farms it surveys, providing a distribution profile of national agricultural GHG emissions (Hennessy et al., 2013). This is part of a development of the NFS quantify a holistic view of sustainability. This data has been further analysed by O'Brien *et al*. (under review), who related on-farm emission intensities to the economic efficiency and performance of individual dairy farms, demonstrating that 'carbon efficiency' is positively related to economic efficiency (Figure 3):

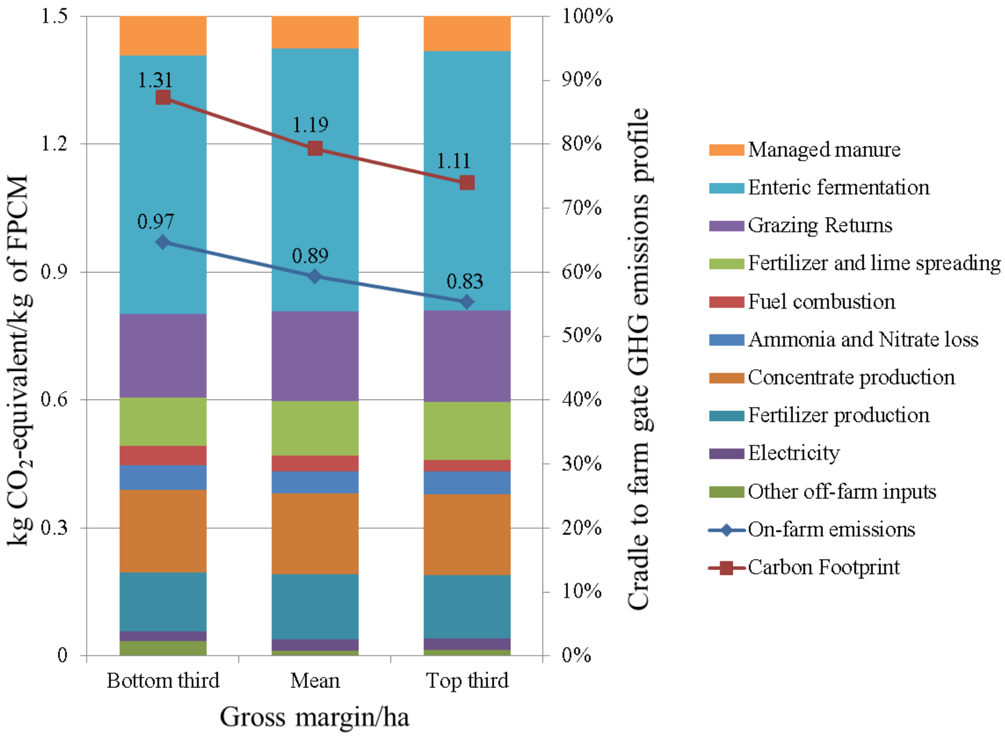


Figure 3: Cradle to farm-gate carbon footprint of Irish milk and greenhouse gas (GHG) emissions profiles for the bottom third, mean and top third of farms in terms of gross margin/ha (Source: O'Brien *et al*., under review).

3.3 Improving the basis for the computation of the National Agricultural Inventories

Inventories of agricultural emissions are by definition associated with large uncertainties

National GHG inventories are required of Annex 1 countries by the United Nations Framework Convention on Climate Change (UNFCCC). These inventories provide baseline and mitigation scenarios for nationally appropriate low emission development strategies. Guidelines for generating national inventories are detailed in the IPCC Good Practice Guidelines (IPCC, 2006). Emissions inventories are compiled for individual sectors by collating those activities that produce emissions (such as fertiliser spreading, methane eructated by dairy cows, fossil fuel burning from cars, etc.). For each activity, a stock is measured, usually from national statistics (e.g. cow population, fertiliser sales, etc.) and multiplied by an emission factor (e.g. amount of methane produced from enteric fermentation per cow) to generate estimates of national emissions for that activity. The degree of accuracy of the inventory will therefore be dependent on 1) accurate collation of activity data and 2) the emissions factors associated with each activity.

Typically, inventories of fossil fuel burning or industrial activity have a relatively low level of associated uncertainty. Power consumption and fuel sales are relativity easy to measure and the amount of CO_2 generated from burning coal or oil is a relatively constant value, regardless of location. However, agricultural inventories are more complex and have a much higher degree of associated uncertainty, due to the biogenic nature of the emissions. For instance, nitrous oxide associated with nitrogen addition to soil will vary with soil type, the form of nitrogen applied and climatic factors such as precipitation and temperature. As a result there is considerable temporal and spatial variation in emissions, which is not reflected in the inventories.

Ongoing research to facilitate more accurate Tier-2 reporting of agricultural GHGs

In addition, whilst mitigation that affects the *amount of an activity* can be counted (e.g. reduced fertiliser, cattle numbers, etc.) any mitigation that affects the *emission factor* cannot currently be captured in the inventories (e.g. changing fertiliser type, timing of fertiliser application, addition of chemicals to reduce methane / nitrous oxide emissions, altering animal breed to reduce methane). As a result, a substantial portion of potential mitigation which has been identified cannot currently be captured in the inventories (O'Brien *et al*. 2014). This is particularly true for nitrous oxide where Tier 1 default emission factors are currently being used in the inventory for Irish agriculture.

For this reason, Teagasc is coordinating the large-scale Agricultural Greenhouse Gas Research Initiative for Ireland (AGRI-I), funded by DAFM, to produce national Tier 2 factors that will dis-aggregate the nitrous oxide emission factors based on fertiliser type, dung and urine deposited N, timing of application and impact of soil type. Under this initiative, further refinement of methane and ammonia emission factors is also being explored. Ultimately, this increased flexibility will bring its own challenges: the associated measuring, monitoring and verification (MRV) methods (i.e. the collation of activity data around timing of fertiliser spreading and land parcel information for instance) will require considerable resourcing pertaining to collating and integrating data from the National Farm Survey, the Ordnance Survey and farming stakeholders.

Similar challenges arise in relation to soil carbon sequestration. This is due to the fact that the input rates of organic C into most soil systems is very small (< 1 t C ha^{-1} yr^{-1}), compared to the background soil organic carbon (SOC) levels (typically 80 - 140 t C ha^{-1}). Whereas quantity and quality of input of carbon via litter fall and plant residues after harvest might be directly measurable, inputs via roots and rhizodeposition are more difficult to assess. The fundamental mechanisms involved are not yet fully understood and there is still no proper quantification of the release of organic and inorganic C compounds from roots or the assessment of seasonal dynamics. This low rate of change also means that statistically significant changes in SOC become detectable only after management practices have been in place for a minimum of ten years (Smith *et al.* 2005). In addition, high resolution land-use and land management activity data is required in order to assess and verify the impact of land-use/ land management change on carbon sequestration. As a result, the MRV of the impact of agricultural management aimed at enhancing soil carbon sinks is challenging.

3.4 Beyond Kyoto: accounting for net greenhouse gas emissions from 'integrated land management'

A new European approach to agricultural greenhouse gas emissions
The European Council Decision of 23-24 October 2014 on the proposed EU Climate and Energy Package for 2030 endorsed a radically new approach to the role of agriculture in mitigating climate change. Paragraph 2.14 of the Decision (which was largely prepared and proposed by Ireland) concludes:

The multiple objectives of the agriculture and land use sector, with their lower mitigation potential, should be acknowledged, as well as the need to ensure coherence between the EU's food security and climate change objectives. The European Council invites the Commission to examine the best means of encouraging the sustainable intensification of food production, while optimising the sector's contribution to greenhouse gas mitigation and sequestration, including through afforestation. Policy on how to include Land Use, Land Use Change and Forestry into the 2030 greenhouse gas mitigation framework will be established as soon as technical conditions allow and in any case before 2020.

Without this decision, the existing EU rules on greenhouse gas accounting would have meant that Ireland would have faced a very stark choice between either meeting Food Harvest 2020 targets as part of the national recovery plan, or meeting EU climate change targets. Instead, this decision opens the door to a new approach towards minimising the impact of agriculture on the global climate, i.e. an approach that is not merely based on reducing direct emissions, but also acknowledges and incentivises the positive effects of agriculture on reducing atmospheric greenhouse gas concentrations, for example through sequestration of carbon dioxide. This new, two-pronged approach (reducing emissions and maximising carbon storage) is referred to as 'integrated land management'.

Teagasc is supporting DAFM and the EPA in assessing options for integrated land management
In this new context, there are multiple potential pathways to optimise this integrated land management, e.g. by increasing sinks, maintaining carbon reservoirs and reducing sources from land. The European Council decision is not prescriptive in how to account for and incentivise this

integrated land management. This is expected to be the subject of further discussions at (and leading up to) the crucial COP21 meeting in Paris, December 2015. As a result, there is now a once-off 8-month window of opportunity in which Ireland can explore and appraise pathways towards integrated land management, and use this appraisal to guide international policy formation.

In response, Teagasc, with funding from the Dairy Research Trust and Agri-I, is working closely with the DAFM Climate Unit and the EPA Climate Unit to assess and appraise management and land use approaches to maximising the carbon sink potential of land, protect the maintenance of carbon reservoirs and minimise carbon losses from land, as well as appraise potential mechanisms and metrics to account for the impacts / effectiveness of integrated land management (sinks, reservoirs, sources – reference and impact of activities).

4 Agriculture: Making it Happen

An integrated approach to policy, knowledge transfer and industry support

The abatement potentials identified in the MACC represent the biophysical maximum abatement potential following complete farmer uptake where appropriate. The original report pointed out that full uptake is unlikely to materialise in the absence of targeted incentivisation measures. Realising this mitigation at farm level is the key challenge facing the sector over the next 10 years. This is particularly challenging in the context of increased agricultural output planned to 2020 and 2025 in the wake of the removal of milk quotas. Positive outcomes will be dependent on the effective integration of the three main element of the tool set that is available to policy makers:

- The implementation of effective policy intervention, both regulatory and incentive based;
- The implementation of effective knowledge transfer initiatives aimed at achievement of practice change and efficiency improvement as identified in the environmental analysis of Food Harvest 2020;
- Involvement of the agri-food industry in efficaciously promoting, incentivising and supporting farmers to move to carbon-efficient production systems.

4.1 Policies on incentivisation

Policy instruments on agricultural greenhouse gases

To date, at national and EU level policy makers have employed a mixture of regulation and incentivisation to achieve environmental outcomes in agriculture. Murphy *et al.* (2013) observed that the main actions in environmental policy include (1) the development of a body of EU directives which are supported by national policy instruments, (2) the establishment of cross-compliance to link environmental compliance to the entitlement for direct payments and (3) the implementation of agri-environmental measures designed to encourage farmers to protect and enhance the environment on their farmland to deliver environmental services above that required by legislation, in return for financial reward.

EU Directives

In relation to EU Directives, the initiatives that have had the biggest impact on GHG emissions in Ireland include the Nitrates Directive and the Water Framework Directive. Both Directives impact on greenhouse emissions through indirect measures, largely relating to nutrient management.

Cross-compliance

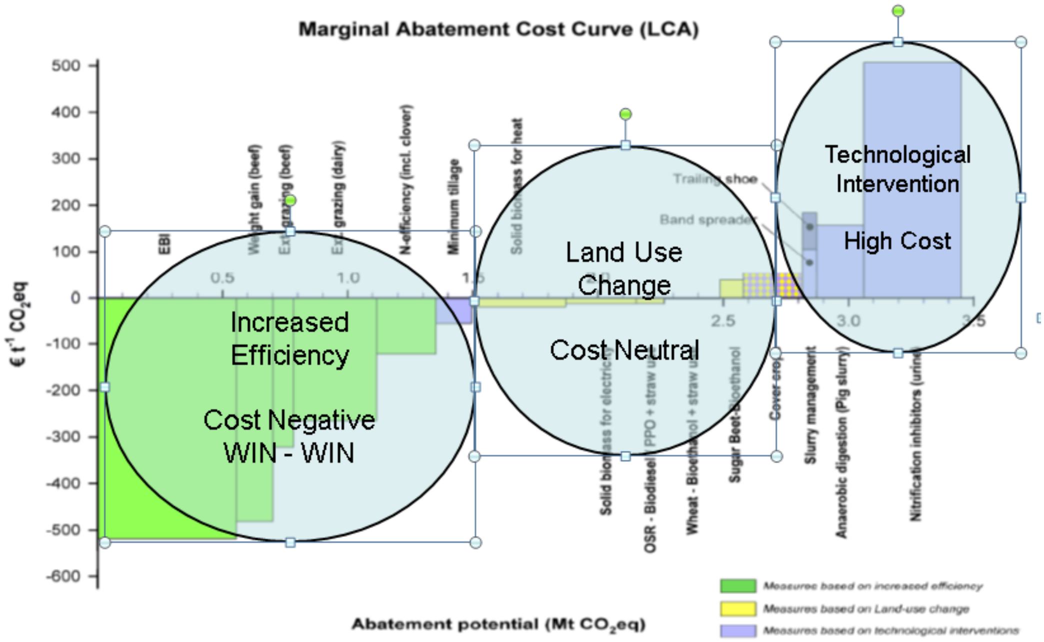
In relation to cross-compliance, the statutory management requirements (SMRs) and good agricultural and environmental conditions (GAEC) provisions do not contain any provisions specifically targeting gaseous emissions, apart from the requirement to maintain soil carbon concentrations above 2%. This latter measure pertained to the maintenance of soil quality, rather than offsetting of GHG emissions, and has proven largely irrelevant for Irish soils, the vast majority of which have carbon concentrations well in excess of this minimum threshold. The “Greening Measures” (Ecological Focus Area, Crop Diversification and Permanent Grassland) which are being implemented as part of the review of the Common Agricultural Policy (CAP), focus to some degree on reducing GHG emissions by limiting the conversion of permanent grasslands to arable land and thus reducing soil carbon losses. However, across Europe, the likely outcome is an equivalent reduction in agricultural GHGs and levels of production. (Van Zeijts *et al.*, 2011; Westhoek *et al.*, 2012).

Agri-environmental schemes
Pillar 2 measures of the CAP, including agri-environmental schemes, have thus far also had marginal impact on reducing emissions. A guiding principle of EU funded schemes is that the calculation of premia is based on cost incurred and income foregone by the farmer for participating in the agri-environmental measure (European Commission, 2005). This means that any measure that leads to an improvement in environmental outcomes, but that also increases farm incomes, cannot be included in EU agri-environmental schemes.

The Commission's evaluation of measures applied to agriculture conceded that with regard to incentivisation measures, there is a lack of more flexible mechanisms aimed at increasing efficiency of agricultural production. This implies that the efficiency measures identified in the MACC curve are presently excluded from supports under agri-environmental schemes. Without a very fundamental change in the principles governing agri-environmental schemes, potential future schemes may have little prospect of incentivising further delivering significant outcomes.

4.2 Knowledge Transfer

Challenges to implementation of the MACC
An examination of the MACC for Irish Agriculture leads to a breakdown of the mitigation options into three groupings. These are set out in Figure 4. The group of lowest cost (or highest gain) options on the left are for the most part achieved through increased efficiency. Supporting these measures will be primarily achieved through the delivery of effective knowledge transfer support for farmers. The second group of measures are mainly land use change options and for the most part are cost neutral. While knowledge transfer can play a role in supporting uptake of these options, these are unlikely to deliver to their full potential without the establishment of incentives to support the establishment and/or the market for the output of the land use change. The third group, based on technological intervention, are for the most part high-cost measures that are currently not advantageous (That is not to say that all future technological interventions are not feasible).



As a result, the adoption of the efficiency measures will be largely based on farmers' efforts to achieve the additional income earning capacity that the measures provide. However, the availability of scientific knowledge on the financial benefit of these measures is, on its own, insufficient to ensure maximum uptake of technologies at farm level. This was pointed out by the EU Standing Committee on Agricultural Research (SCAR) (Gaudin et al., 2007), which observed that there is a need to invest more seriously in knowledge transfer and knowledge exchange measures to ensure that knowledge leads to practice adoption and innovation.

Existing knowledge transfer measures

In most European countries, state support for agricultural knowledge transfer has been reduced dramatically. Ireland is one of the few countries that retain a state-funded extension or advisory service. Increasingly, the EU Commission has recognised the need to support knowledge transfer in the achievement of productivity and environmental objectives in the agriculture sector. In this context the pending introduction of the Knowledge Transfer Measures, which support discussion groups as part of the RDP, and the proposed focus within that measure on carbon efficiency, is to be commended.

Over the last five years the Department of Agriculture Food and the Marine has introduced a series of innovative technology transfer support measures. These have included the Dairy Expansion Programme (DEP), the Beef Technology Adoption Programme (BTAT) and the Sheep Technology Adoption Programme (STAP). These innovative programmes provided direct support to farmers to participate in advisory discussion groups and to complete tasks aimed at improving the technical and financial performance of the participants. An end-of-programme evaluation of the DEP found that dairy discussion groups are an effective mechanism in the delivery of advice; are impacting on management and efficiency; and are generally delivering to the expectations of farmers. The improvements targeted and achieved in the DEP, with a primary focus on improved genetics, improved grassland management and grazing season length, improved nutrient efficiency and increasing output levels are consistent with the increased efficiency measures set out in the MACC.

New knowledge transfer measures

Based on the success of these programmes the Department of Agriculture Food and the Marine have built on this model in the development of a series of Knowledge Transfer measures, as part of its 2014-2020 rural development programme (RDP). The inclusion of the completion of the Farm Carbon Navigator as a specific measure in these schemes is aimed at improving farmer awareness and performance in relation GHG mitigation and will provide significant support for the improvement of the carbon efficiency of Irish agricultural output. The Carbon Navigator has been developed as a tool to be used as part of the knowledge transfer activities of Teagasc to improve the understanding of agricultural GHG amongst transfer professionals and farmers. It supports the uptake by farmers of a series of technologies that will improve efficiency and income while at the same time reducing GHG emissions intensity.

New knowledge transfer measures

In Section 2.3, we discussed the importance and urgency of maximising the value added of dairy beef systems in the context of reduced suckler cow numbers, which is required to ensure that further growth of the industry post 2020 does not result in a concomitant increase in agricultural GHGs. To achieve this, a number of enabling support initiatives are required, aimed at developing and incentivising more profitable production systems from dairy beef calves through the use of sexed semen, high quality terminal beef sires for the dairy herd and an improvement in technical performance on beef farms through a reduction in the slaughter age.

The further upscaling of existing and new Knowledge Transfer activities, as recommended by the Environmental Analysis of Food Harvest 2020 (Farrelly, 2014), will require significant funding and resources.

4.3 Industry and Markets

Most industry actors have embraced the concept of carbon-efficient farming as a Point of Differentiation and hence an opportunity for marketing Irish produce in premium markets. This has resulted in a large number of industry initiatives, which have been brought together under Bord Bia’s Origin Green programme. These initiatives are important levers to continued adoption of best practices, as they provide synergy between production and sustainability objectives.

A prerequisite to effective industry initiatives is that they are based on, and aligned with, the latest scientific and technical knowledge. For this reason, Teagasc collaborates closely with a large number of Industry initiatives. Most notable is the joint development of the Carbon Navigator by Teagasc and Bord Bia. In utilising data from the Bord Bia Sustainable Dairy Assurance Scheme (SDAS), Department of Agriculture Food and Marine databases, Irish Cattle Breeders Federation (ICBF) databases and from dairy processors the Carbon Navigator provides a basis for a co-ordinated industry wide approach to achieving mitigation at farm level especially with it proposed inclusion in the knowledge transfer measures in the RDP.

Teagasc will continue to support these industry initiatives in the form of Industry funded, core funded and competitively funded projects. Teagasc has been responsible for the development of the models and decision support tools that are currently been used by Bord Bia for the footprinting of beef and dairy (O'Brien *et al.*, 2014) and are currently developing a similar model for sheep meat in conjunction with Bord Bia. Teagasc will continue to develop and support these models with Bord Bia in line with industry requirements.

5 Toward Integrated Land Management

5.1 Context

In our 2013 report (Teagasc, 2013), we assessed long-term opportunities to reduce the 'net agricultural emissions', i.e. opportunities for offsetting of agricultural emissions in a post-Kyoto UNFCCC scenario. We identified accelerated afforestation as the most promising pathway within the Irish agricultural context, and highlighted the potential and constraints for bio-energy production. The opportunity for these pathways was given credence by the recent European Council decision, which called on the European Commission to "examine the best means of encouraging the sustainable intensification of food production, while optimising the sector's contribution to greenhouse gas mitigation and sequestration, including through afforestation".

An integrated approach to a) reducing agricultural emissions and b) enhancing offsetting through carbon sequestration has since become known as 'Integrated Land Management'. In this section, we assess progress towards integrated land management since our last report in 2013.

5.2 Forestry Programme 2014 – 2020

The need for further expansion of the Forestry Programme

The contribution of forestry and forests to GHG mitigation is dependent on achieving a critical mass of productive forests. Use of timber in higher end uses, such as the construction industry, is likely to ensure a longer carbon lifespan and may hence deliver more greenhouse gas offsetting benefits than use of timber in lower-value end uses such as biomass.

Government policy has reiterated its commitment to expand the productive forest area to approximately 1.25 million ha or 18% of the land area by 2046 (http://www.agriculture.gov.ie/media/migration/forestry/publicconsultation/newforestryprogramme2014-2020/forestryprogramme2014-2020/DraftForestryProgramme20142020PubCon.pdf). Currently this would require annual afforestation targets of 16,000 hectares per annum. The sequestration potential of lower levels of forest planting is limited as forestry and carbon sequestration is disproportionally dependent on an 'early start' to achieve higher rates of planting. For example increasing planting from 8,000 to 20,000 hectares per annum may reduce national agricultural emissions by half (Teagasc, 2013). The current programme plans to increase forestry planting to approximately 7,300 ha annually for the next 6 year, i.e. less than half the planting rate required to meet the target of 18% forest area by 2046. The proposed planting rate of 7,300 ha per annum is insufficient to increase offsetting of agricultural emissions. In fact, it is below the rate required to simply maintain offsetting level beyond 2030, thus making future planting targets even more onerous. Levels of planting in the order of 20,000 ha have been achieved in Ireland in the past and are therefore technically and logistically feasible. However this becomes increasingly challenging as additional land is afforested. In order to achieve 18% forest cover it will be necessary to extend the period of afforestation envisaged beyond 2046 assuming an afforestation programme of circa

15,000 ha per annum (Forest Policy Review).
http://www.agriculture.gov.ie/media/migration/forestry/forestpolicyreviewforestsproductsandpeople/00487%20Forestry%20Review%20-%20web%2022.7.14.pdf

In summary, achieving the ambition for 2046 will necessitate an immediate additional and concerted effort, combining incentivisation and promotion with effective support and targeting for forest planting while revisiting policies on land suitability for afforestation.

Resolving competing demands on land

These higher levels of afforestation will necessitate significant efforts to mobilise land use change to facilitate forestry expansion. This is currently constrained by, *inter alia*, the availability of land, owing to competing land uses such as the planned expansion in the agricultural sector and constraints posed by policies including conservation policies. Given that 4.6 million hectares are currently in agriculture (CSO, 2010), future forestry expansion is disproportionally dependent on individual farmers converting from agriculture to forestry. In principle, forestry represents an excellent land use option for much of the land that is marginal to economic agriculture, by virtue of soil type, trafficability or topography.

However, policy and conservation constraints may limit or preclude forestry expansion or land use change. Where competing environmental objectives exist, there may be merit in considering strategies that optimise the totality of environmental benefits. It is important that the multiple objectives of forestry, such as raw material provision, diversification, water protection, recreation are evaluated in addition to carbon sequestration and that the relative importance of these objectives and rationale for these are devised. The Department of Agriculture, Food and the Marine is actively considering these matters as part of the COFORD land availability working group (CCLAWG).

Research requirements

There is a need to examine all current information to characterise the potential suitability of land for forestry and to establish the extent of availability of these land types. It is important that forest land remains productive in order to maximise its potential for GHG mitigation. There is a clear link between species-productivity and carbon sequestration which needs to be reconciled. Therefore, appropriate species selection, and protection of the carbon resource are crucial. The future proofing of genotypes in response to climatic changes requires further research. This knowledge will assist in the assessment of opportunities and constraints for forestry expansion and the levels of carbon sequestration that can be provided for.

5.3 Bio-energy

In its 'qualitative assessment of potential pathways towards carbon neutrality as a horizon point', Teagasc (2013) highlighted bioenergy production and AD of grass are technically promising land use options. However, it also emphasised that the uptake to date of these technologies has been very low in Ireland, and offered three potential constraints as explanations for this low uptake to date: i) the availability of land, ii) capital investment requirements and iii) the economic/policy/legislative environment with specific emphasis on the REFIT tariff.

Apart from the continued use of biomass for co-firing in Edenderry power station along with some activity in the industrial heat sector, there is little activity in the bioenergy sector at present. The government has published a draft bioenergy plan which several working groups are working on the finalisation of this plan at present. Any future submissions from Teagasc will comment on the completed plan when it is published.

6 Climate Change and Risk - Resilience

We take note that adaptation to the impacts of climate change will be addressed in a parallel national plan, i.e. the forthcoming Adaptation Discussion Document for the Agriculture and Forest Sectors. Teagasc will prepare a separate submission on adaptation to climate change as part of this parallel process.

References

CSO, 2010. Central Statistics Office Databases, Central Statistics Office, , Cork, Ireland http://www.cso.ie/px/pxeirestat/Statire/SelectVarVal/Define.asp?maintable=AQA05&PLanguage=0

European Commission (2005). Study of the European Commission Directorate General for Agriculture and Rural Development, Unit G-4-Evaluation of Measures applied to Agriculture, March. European Commission, Directorate General for Agriculture and Rural Development, Brussels, Belgium, pp. 1-23.

European Council (2014). European Council (23 and 24 October 2014) Conclusions on 2030 Climate and Energy Policy Framework. http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145356.pdf

FAO, 2010. "Greenhouse gas Emissions from the Dairy Sector: A Life Cycle Assessment". Food and Agriculture Organization, Rome. http://www.fao.org/agriculture/lead/themes0/climate/emissions/en/

Farrelly, P., 2014. Food Harvest 2020: Environmental Analysis Report – Final Report. Department of Agriculture, Food and the Marine, Dublin. http://www.agriculture.gov.ie/media/migration/ruralenvironment/climatechange/FoodHarvest2020EnvironmentalAnalysisFINAL050214.pdf

Gaudin, T., Cassingena-Harper, J., Anania, G., Cuhls, K., Downey, L., Leyten, J., Olesen, J. E., Schenkel, Y., Walls, M. and Raspor, P. (2007) Standing Committee on Agricultural Research, European Commission.

Hennessy, T., Buckley, C., Dillon, E., Donnellan, T., Hanrahan, K., Moran, B., Ryan, M., 2013. Measuring Farm Level Sustainability with the Teagasc National Farm Survey. Teagasc, Athenry. http://www.teagasc.ie/publications/2013/3042/SustainabilityReport.pdf

Intergovernmental Panel on Climate Change (IPCC), 2006. In: Eggleston, H.S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. (Eds.), 2006 IPCC Guidelines for National Greenhouse Inventories, vol. 4. Agriculture, Forestry and Other Land Use. Institute for Global Environmental Strategies (IGES), Hayama, Japan.

Leip, A., Weiss, F., Wassenaar, T., Perez, I., Fellmann, T., Loudjani, P., Tubiello, F., Grandgirard, D., Monni, S. and Biala, K., 2010. Evaluation of the livestock sector's contribution to the EU greenhouse gas emissions (GGELS) – final report. European Commission, Joint Research Centre, 323 pp.

Murphy, P., Crosson, P., O'Brien, D., Schulte, R.P.O., 2013. The Carbon Navigator – a decision support tool to reduce greenhouse gas emissions from livestock production systems. Animal: International Journal of Animal Bioscience, 7:s2, pp 427-436.

O'Brien, D., Shalloo, L., Crosson, P., Donnellan, T., Farrelly, N., Finnan, J., Hanrahan, K., Lalor, S., Lanigan, G., Thorne, F., Schulte, R.P.O., 2014. An evaluation of the effect of greenhouse gas accounting methods on a marginal abatement cost curve for Irish agricultural greenhouse gas emissions. Environmental Science and Policy 39, 107-118.

O'Brien, D., Hennessy, T., Moran, B., Shalloo, L., under review. Relating the carbon footprint of milk from Irish dairy farms to economic performance. Submitted to the Journal of Dairy Science.

Smith, J.U., Smith, P., Wattenbach, M., Zaehle, S., Hiederer, R., Jones, R.J.A., Montanarella, L., Rounsevell, M., Reginster, I., Ewert, F., 2005. Projected changes in mineral soil carbon of European croplands and grasslands, 1990–2080. Global Change Biology 11, 2141–2152.

Teagasc, 2011. Irish Agriculture, Greenhouse Gas Emissions and Climate Change: opportunities, obstacles and proposed solutions. Teagasc submission to the proposed Government Climate Change Response Bill. Teagasc, Carlow. http://www.teagasc.ie/publications/2011/61/61_ClimateBillSubmission.pdf

Teagasc, 2012. A Marginal Cost Abatement Curve for Irish Agriculture. Teagasc submission to the public consultation on Climate Policy development. Teagasc, Carlow. http://www.teagasc.ie/publications/2012/1186/1186_Marginal_Abatement_Cost_Curve_for_Irish_Agriculture.pdf

Teagasc, 2013. Carbon-Neutrality as a horizon point for Irish Agriculture: a qualitative appraisal of potential pathways to 2050. Teagasc, Carlow. http://www.teagasc.ie/publications/view_publication.aspx?PublicationID=3002

Van Zeijts, H., Overmars, K., van der Bilt, W., Schulp, N., Notenboom, J., Westhoek, H., Helming, J., Terluin Ida and Janssen, S. (2011). Greening the Common Agricultural Policy: impacts on farmland biodiversity on an EU scale. PBL Netherlands Environmental Assessment Agency, The Hague, Netherlands. http://www.pbl.nl/en/publications/2011/greening-the-common-agricultural-policy-impacts-on-farmland-biodiversity-on-an-eu-scale

Westhoek, H., van Zeijts, H., Witmer, M., van den Berg, M., Overmars, K., van der Esch, S. and van der Bilt, W. (2012). Greening the CAP: an analysis of the European Commission's proposal for the Common Agricultural Policy. PBL Netherlands Environmental Assessment Agency, The Hague, Netherlands, pp. 1-30.