

Ag Climatise

A Roadmap towards Climate Neutrality



Department of Agriculture, Food and the Marine

A Roadmap towards Climate Neutrality

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Foreword

Agriculture has a critically important social, economic and environmental value to Ireland. Farmers are the custodians of our physical environment and have been engaged in environmental action for generations. With increasing evidence of accelerating climate change and environmental degradation, there is a broad consensus both nationally and internationally, that urgent action is required across all sectors. This societal consensus is reflected in commitments, both legal and political, to which countries that are serious about the environment have signed up to.



Like other sectors, agriculture will play its part in meeting these national and international obligations. Against this background, it is important that we find the right balance between the multiple objectives placed on agriculture and land use. We must ensure that agriculture contributes to climate change mitigation and the protection of the environment, but also that it continues to support vibrant rural and coastal economies and communities. The farmer is at the heart of this transition. We need to work with farmers to make the changes needed to achieve our climate goals, while at the same time protecting the economic viability of our primary producers and those that depend on their output for high quality food and downstream employment.

Across Europe, agriculture is about to undergo a period of significant change. Farmers can embrace these changes in the knowledge that much of what is being asked of them can contribute to improving overall farm profitability, and that there are strong synergies between environmental performance and market dynamics. The corollary is also true. It is clear that if we fail to address the impact of agriculture on climate change and the environment, Ireland's reputation as a source of high quality food produced to the highest environmental standards will be damaged.

Given the EU and Ireland's target to become a climate neutral economy by 2050, agriculture's commitment will have to evolve over time, necessitating a step up in ambition with a whole of government, whole of sector approach.

In the medium to longer term, a significant cut in biogenic methane emissions will be needed to negate the global warming impact of biogenic methane. Developments in technology (e.g. breeding and feed additives) can underpin this required reduction. Other agricultural emissions of nitrous oxide (including emissions from animals grazing at pasture, manure management and fertiliser application) will need to be offset by removals, and agriculture can also make a substantial contribution to renewable energy.

With this in mind, we need to start implementing changes on farms today.

A handwritten signature in black ink that reads "Charlie McConalogue". The signature is written in a cursive, slightly slanted style.

**Charlie McConalogue T.D.
Minister for Agriculture, Food and the Marine**

Introduction

The global community faces a future in which we need to balance the need to increase food and fibre production, with helping farmers, foresters, fishermen and society generally to reduce greenhouse gas (GHG) emissions, build resilience and adapt to the impacts of climate change.

This roadmap has been developed by the Department of Agriculture, Food and the Marine (DAFM) on foot of extensive engagement with industry, research, policy, farmer and environmental stakeholders. It is a roadmap designed to help all stakeholders to work together to tackle climate change and air pollution, by clearly explaining what we need to do and when we need to do it. By collectively pooling expertise and energy we can determine how best to do it, ensuring our sector remains at the forefront of globally sustainable food production systems.

Our Obligations

Climate

The Programme for Government, and the [recently published Climate Action Amendment Bill 2020](#), sets out the objective to achieve a '**climate neutral economy**' which balances emissions and removals within the State by the end of 2050 and in subsequent years.

Under the Paris Agreement, Ireland and other countries have committed to limiting temperature rise to less than 2 degrees above pre-industrial levels and pursue efforts to limit temperature rise to less than 1.5 degrees.

As a member of the EU, Ireland's target to reduce emissions in line with the Paris Agreement goals is guided by the EU Climate and Energy Framework. The EU Commission recently announced its new European Green Deal agenda, including a [Farm to Fork strategy](#) and [Biodiversity strategy](#). It is clear that at a whole of economy level, environmental ambition must be stepped up to meet the recently increased EU target of 55% reduction in emissions by 2030. Agriculture will have to play its part. This roadmap has been developed to deliver the 2030 climate ambition as set out in the 2019 Climate Action Plan, and will be updated as the Climate Action Plan is revisited to reflect the stronger climate ambition in the Programme for Government.

- In Ireland, agriculture remains the single largest contributor to overall emissions at 35% (2019 Provisional EPA report) of the total. At the same time, the agriculture and land use sector (including forestry) has a key role to play in developing renewable energy systems and in sequestering carbon from the atmosphere.

Air

The National Emission Ceilings Directive establishes limit values for five air pollutants to help mitigate their impact on Member State populations. Upon exceedance of these limit values, Member States must implement air quality plans to assess and combat the problem.

One of these air pollutants is ammonia, and it comes almost exclusively from the agriculture sector. Under the National Emissions Ceiling Directive, Ireland has an ammonia target of 107,500 tonnes in 2030. The most recent EPA Air Quality report (June 2020) indicated that there were 119,339 tonnes of ammonia produced in 2018.

- In Ireland, agriculture is responsible for 99% of ammonia emissions, with projections going forward to 2035 showing that increased dairy cow numbers will be a driver of the increased emissions due to their high nitrogen excretion values relative to other livestock.

Co-Benefits

While the primary focus of this roadmap is on GHG and ammonia emissions, it is clear that achieving our targets for climate and air will also have positive co-benefits for water quality and biodiversity. This roadmap also speaks to our One Health One Welfare ambitions.

Our Vision

By 2050, we want to develop a climate neutral food system compatible with the Paris temperature goals, whereby the climate impact of biogenic methane is reduced to zero and remaining agricultural emissions are balanced by removals through land use and a significant contribution to renewable energy.

There are six key tasks that we need to achieve to meet our climate and environmental objectives, while maintaining viable farm incomes in the sector.

1. Reduce GHG emissions from the sector. Methane from enteric fermentation and nitrous oxide are the dominant GHGs from agriculture.
2. Increase the carbon sequestration and carbon storage potential of Ireland's land use sector.
3. Reduce nutrient loss to the environment and contribute to improved water quality and biodiversity.
4. Meet our ammonia emissions reduction targets.
5. Build sustainable, resilient food production and land use management systems that meet these climate and environmental obligations, while also meeting market expectations.
6. Transparently communicate our progress; our Origin Green programme can play a key role in this regard.

Context

Due to our maritime climate and exceptional ability to grow grass at relatively low cost, there is a higher reliance on livestock farming in Ireland. It is well understood that emissions in agriculture have two key drivers - livestock numbers and fertiliser use.

- Biogenic methane (CH₄) from livestock accounts for the greatest share of this, approximately 65% of the total agriculture emissions, and;
- Nitrous oxide (N₂O) is the other potent GHG (30% of total) with approximately 40% of these emissions being associated with chemical nitrogen fertilisers.

In total, approximately 80% of the agricultural GHG inventory is related directly to the number of animals and the management of the manure they produce.

This roadmap is based on stabilising methane emissions and a significant reduction in fertiliser related nitrous oxide emissions, leading to an absolute reduction in the agricultural greenhouse gas inventory by 2030. Any increase in biogenic methane emissions from continually increasing livestock numbers will put the achievement of this target in doubt.

Our Approach

In order to respond to the challenge in a coherent and coordinated manner on a whole of government, whole of sector basis, this roadmap can guide the development of an agri-food sector that is built on environmental sustainability and climate resilience, and contributes fairly to Ireland's climate, air and energy targets.

Many of the actions referenced in this roadmap are based on the Teagasc Marginal Abatement Cost Curves (MACCs) for GHG and ammonia and can be acted on immediately. Other actions will need further consideration, and in collaboration with stakeholders, we will establish expert groups to oversee the development and implementation of actions where a path to delivery is unclear. This roadmap proposes two strands of activity:

Actions that can be implemented now: to ensure farmers act immediately on the changes necessary to address climate change. This is made up of three parts, the mitigation measures in the next section, the removals from the landscape measures, and the sustainable energy measures that follow.

The development of cross cutting enabling actions into the future: This will focus on a number of actions, including further research and innovation. Where appropriate, it will require the establishment of consultative groups to assist with the development and delivery of the actions.

Changes that can be implemented now:

Fertilisers

Chemical nitrogen use is responsible for approximately 40% of nitrous oxide emissions on Irish farms. It also contributes to ammonia emissions, mainly through the application of urea based fertilisers. Chemical nitrogen use on Irish farms peaked at 408,000 tonnes in 2018. This must be reduced to a target level of 350,000 tonnes by 2025, with a further reduction to an absolute maximum of 325,000 tonnes by 2030, equivalent to the usage in 2013. In line with the EU Farm to Fork Strategy, chemical nitrogen use will come under ever closer scrutiny in the years ahead, particularly with regard to water quality. This measure will complement other policy objectives in areas such as air and water quality and the role of the Good Agricultural Practices (GAP) regulations to control nitrogen usage at farm level where approximately 55,000 farmers use an online nutrient management plan. The sector needs to find a way to reduce chemical nitrogen use, without compromising its ability to grow food, feed and fibre, while maintaining the pasture-based diet of our national herd. Over 50% of chemical nitrogen usage is in the dairy sector and therefore this must be a key focus area.

Over the course of the next decade, the sector should target a 50% reduction in nitrous oxide emissions associated with chemical fertiliser use. By delivering on Actions 1 and 2, the sector can meet this high level ambition.

Action 1: Reduce chemical nitrogen use to an absolute maximum of 325,000 tonnes (annually) by 2030, with an interim target of 350,000 tonnes by 2025

This can be achieved by focusing on the following sub-actions:

- Optimise delivery of online nutrient management planning to deliver a user friendly and practical experience for all farmers.
- Working closely with the public and private sectors including the advisory services, academics, soil scientists, agricultural technology companies, and the fertiliser industry representatives, farmers must make better use of soil and nutrient management planning.
- A national liming programme for mineral soils to be rolled out by industry in 2021 which will contribute to improved nitrogen use efficiency for both organic and chemical fertilisers. Liming levels are increasing (currently 1m tonnes per annum), but they are still below historic levels. (1.7m tonnes per annum in 1980s.) Over the course of the next decade, target usage of 2m tonnes per annum.¹

¹ While increased liming will lead to an increase in CO₂ emissions in the agricultural inventory, the net benefit will be improved nutrient use efficiency (NUE), subsequent reduced fertiliser use and abatement of nitrous oxide emissions which will more than exceed any CO₂ increase.

- Support the use of non-chemical nutrients such as bio-based fertilisers and soil conditioners through greater visibility of the fertiliser marketing regulations.
- Achieve a target of 60% of all slurry spread by low emissions slurry spreading by 2022; 80% by 2025; and 90% by 2027. By getting better nitrogen recovery from organic manures, chemical nitrogen demand on the farm will be lower. This action will make a significant contribution towards meeting our ammonia reduction targets.
- Where possible, and in addition to the usage of LESS, apply organic manures in the spring.
- From 1st January 2022, require all newly constructed external slurry stores to be covered. In addition, all existing external slurry stores should be covered as soon as practically possible, but no later than 31st December 2027. This will reduce ammonia losses from the stores, keeping more of the valuable nitrogen in the slurry, and thereby contribute to the reduction in chemical nitrogen usage.
- Require incorporation and maintenance of clover (and mixed species) in all grass reseedings by 2022, facilitating a reduction in chemical nitrogen use.
- Where appropriate, consider use of leguminous crops.

Action 2: Where chemical fertiliser is applied, promote the use of protected nitrogen products

- Prohibit the use of urea, replacing with a urease inhibitor treated urea product (protected urea*) by end of 2023.
- Aim to have 65% of straight Calcium Ammonium Nitrate (CAN) sales as protected urea/protected nitrogen** by 2030. The action should have a linear uptake over the decade.
- In order to achieve these targets, the fertiliser industry will need to work proactively with the agri-food sector. An information portal on protected nitrogen products should be established and maintained.

*Protected urea is currently available on the market and complies with ALL relevant standards under the Fertiliser Regulations. The Department will continue to work with all stakeholders to ensure its continued safe and effective use.

** While protected urea is the commercially available form of protected nitrogen currently available, the Department recognises that other innovations may emerge over the coming years which could contribute to this action.

Animal Breeding

Animal Breeding has been identified as a concrete action that will not only reduce the environmental footprint on farm but will also increase farm profitability. Dairy farmers will be familiar with the Dairy Economic Breeding Index (EBI). Research has proven that higher EBI cows improve several traits of economic importance. Crucially, these higher EBI cows also improve the carbon footprint of finished products. There is a real opportunity to build on the progress made to date by accelerating action in this area. With all stakeholders in the supply chain working together, significant improvements can be made over the next decade, and this is the focus of Action 3.

Similarly, on the beef side, breeding can make a huge contribution to more carbon efficient animals. The ICBF beef Eurostar index, supported by schemes from the Department such as the Beef Data and Genomics Programme (BDGP) and the Beef Environmental Efficiency Programme (BEEP), have underpinned these improvements. In an ever more competitive international marketplace, the consumer is demanding higher quality beef products, produced in an environmentally friendly way. Ireland must occupy this space into the future. One of the biggest contributions beef farmers can make on the ground is to finish their animals earlier. While breeding will make a contribution here, management practices will also be key in this regard.

National genotyping will have the added advantage of further improving our traceability credentials which are an essential element of maintaining exports and also meeting growing consumer demand for farm to fork information.

Action 3: Genotype the entire national herd by 2030 to underpin the development of enhanced dairy and beef breeding programs that help achieve a reduction in our overall GHG output at a national level

- In terms of achieving the overall genotyping objective, commence with all calves in priority categories of herds in 2021, e.g. herds in the Beef Data and Genomics (BDGP) programme. While this overall objective is ambitious, it is the single most important measure the industry can do to improve animal breeding on Irish farms and further enhance traceability.
- Farmers should plan and transition away from the use of stock bulls for replacements in dairy herds by 2025. This will accelerate progress in the national EBI.
- Explore opportunities to better integrate the dairy and beef sectors, focusing particularly on dairy calf to beef systems.
- Increase the number of dairy herds in milk recording from the current level of 50% to 90% and suckler beef herds in beef weight recording from the current level of 30% to 70%.
- Achieve targeted improvements in key metrics relating to age at slaughter and age at first calving for our national dairy and beef herds.

Improved Grassland Management

Increasing the proportion of grazed grass in the feed budget and reducing the proportion of grass silage in the diet improves feed digestibility and quality. Improving the digestibility and quality of feed consumed reduces methane emissions because of improvements in animal productivity, as well as reductions in the proportion of dietary energy lost as methane. Furthermore, extended grazing reduces the period manure is stored, thereby reducing methane emissions generated during this storage period. Grazing conditions must be considered at all times. Improved grazing management achieved through grass measurement and allocation will increase grass production and utilisation without a requirement to increase N fertiliser use. Increasing grass as a proportion of the animal's diet will reduce the requirement for imported feed, thus reducing nitrogen imports onto the farm.

Action 4: Maximising production of grazed grass

- Develop national training and mentoring programs for grassland/pasture management on dairy and beef farms.
- Roll out the Grass10 training to a greater cohort of beef and dairy farmers.
- Recording of grass production on all farms above 100 livestock units or 130 kg Organic N per ha is required.

Animal Health

Improvements in the herd health status of the national Irish dairy and beef herd leads to increased productivity and ultimately reduced emissions per unit of product. Animal breeding can make significant contributions to the development of more healthy animals. There is an onus on the entire sector to work collectively to make targeted improvements over the coming decade. This will not only reduce the carbon footprint of Irish farms, but it will also increase farm profitability. Much like nutrient use efficiency, it is a win-win for the farmer and the environment. The development of antimicrobial resistance is a concern in veterinary, as well as human medicine, and to protect the efficacy of such products into the future, the EU Farm to Fork strategy requires a reduction in the use of antimicrobials over the coming decade.

Action 5: Further enhance animal health strategies to support climate ambitions and environmental sustainability through promotion of sustainable animal health and welfare practices and enhancing food safety and authenticity

- Completion of Bovine Viral Diarrhoea (BVD) eradication by 2023.

- Significantly reduce the prevalence of Bovine Tuberculosis in the national herd.
- Increase the level of participation in the Irish Johne's Control Programme (IJCP) by expanding this beyond dairy herds.
- Develop a programme to reduce prevalence levels of Infectious Bovine Rhinotracheitis (IBR).
- Targeted improvements in national somatic cell count over the next decade.
- Continue to improve the welfare of the Irish herd, with particular emphasis on lameness in dairy herds.
- Develop breeding programmes to take account of liver fluke, antimicrobial resistance, anthelmintic resistance, Johne's disease, and IBR heritability, with a firm focus on animal welfare at all times, are required. This needs to be done with adaptation to a changing climate in firm focus (Linked to Action 3).

Crude Protein, Feed Additives and Livestock Rations

The level of crude protein in an animal's diets is crucial. Too much, not only adds to the cost of the ration, but also leads to increased environmental pressure through ammonia loss from the manure produced. Action 6 focuses on this issue.

In addition, progress is being made on feed additives that reduce methane production in the rumen. Further work is needed to prove the abatement potential of these emerging products before commercialisation can begin. This is the purpose of Action 7.

In addition, the sector needs to increase the proportion of home grown feeds in livestock rations (Linked to Action 8).

Action 6: Reduce the crude protein content of livestock feeding stuffs to minimise ammonia loss

- Reduce the average levels of crude protein in pig feeds to 16%
- Apart from some limited situations where nutritional science indicates that animals have higher protein requirements, reduce the levels of crude protein in feeds for grazing ruminants to a maximum of 15%.
- Where practical, feed manufacturers and co-operatives should increase the content of native grains and proteins in compound rations. Where feasible, these rations should be labelled accordingly.

Action 7: Continue to invest in novel feed additives to reduce biogenic methane

- The Department to support research into diet quality and use of novel feed additives in pasture based production systems to reduce methane emissions. Industry, along

with the research community, need to commercialise the use of feed additives, while taking full account of their safety profile at all times.

Action 8: Increase the proportion of home grown protein in livestock rations

- The livestock sector in Ireland is over reliant on imported feed. The sector must take steps to increase the proportion of native grains and legumes in livestock rations. This will further strengthen the sustainability credentials of the Irish agri-food sector, creating a demand stimulus and contributing to the circularity of the agri-food sector (Linked to Action 10).

Organic Farming

In January 2019, a new Strategy for the Development of the Organic Sector for the period 2019 to 2025 was launched. This acknowledged the importance of promoting organic food production, not only through having regard to market demand but also by giving due consideration to climate change mitigation and biodiversity protection. Some 74,000 ha of Ireland's utilisable agricultural area is now under organic production, which represents an increase of over 50% on the position at the start of the Rural Development Programme in 2014. There is a growing consumer demand for organic products, and Ireland's green image in the international marketplace gives us a real opportunity to further develop the sector, while simultaneously having a positive impact on the environment. Ultimately growth will be demand led.

Action 9: Increase the current area under organic production to 350,000 hectares by 2030

- In line with the general direction of the EU Farm to Fork Strategy, develop the organic farming sector through enhanced marketing support to stimulate demand and increase appropriate targeted supports to facilitate conversion and maintenance of land under organic production.

Tillage and Horticulture Sectors

The tillage and horticulture sectors are the most carbon efficient sectors of Irish agriculture, hence it is important that the area under cultivation in these sectors is retained, at a minimum, or indeed increased. Currently, there are approximately 300,000 hectares of tillage crops (cereals, legumes and potatoes) produced annually and this area must be retained, despite increasing land competition from the dairy sector. There is also an opportunity for industry to exploit opportunities for high value crops, based on changing consumer preferences, creating opportunities for the primary producer. There is a very clear opportunity to increase the volume of Irish grain being used in the high value drinks industry, and as a source of protein for the livestock industry (Linked to Action 8). Over the next decade, there is the potential to produce 40,000 ha of beans which would provide a native source of proteins. At a producer level, there are several nitrogen use efficiency measures that tillage farmers can consider to further reduce the environmental footprint of their holdings.

Action 10: Increase the area under tillage production above the current area of 300,000 hectares by 2030, producing more native grown grains and legumes for the livestock industry, while further enhancing the environmental credentials of the sector

- Encourage the use of winter grown cereals. Farmers growing spring cereals should consider the use of cover crops to increase nitrogen use efficiency at farm level.
- Consider buffer strips to minimise the loss of soil organic matter through erosion, help retain soil, and potentially improve, soil carbon levels, reduce sediment loss, and increase biodiversity.
- Where appropriate, consider using leguminous crops as a break crop to reduce the requirements for chemical nitrogen in a subsequent crop. In addition, these natively produced proteins will reduce the national feed import requirement (Linked to Actions 1 and 8).
- Where practical, adopt minimum tillage on farms to protect soil carbon pools. Consideration should also be given to straw chopping and incorporation post harvest on a set area nationally. The Department will consider.
- Explore opportunities to further develop markets for the higher value food and drinks sector e.g. Malting barley and rye for distilling, wheat and oats for milling, hemp for oil production.
- Consideration should be given to aligning the Irish Grain Assurance Scheme (IGAS) with Bord Bia's Quality Assurance Schemes in order to encourage end users to source certified sustainable cereals.
- Where practical, source organic manures for application to tillage land. Aim to have all organic manures applied to tillage land incorporated within 4 hours of application,

to reduce ammonia losses and maximise the nitrogen replacement value of these manures.

Action 11: Further enhance carbon credentials of the horticulture sector

- Explore opportunities to expand and support domestic vegetable production. For example, in 2017, Ireland imported 72,000 tonnes of potatoes and 30,000 tonnes of carrots.
- Further enhance and support the Producer Organisation model, giving growers greater leverage when dealing with the retail sector.
- Consideration should be given to planting more fruit and nut trees (such as apples, hazels) within all agricultural enterprises. Expanding domestic fruit production would improve national food security and increase on farm carbon sequestration.
- Investigating how the bioeconomy can interact and synergise activities in a circular fashion that deliver organic nutrients to primary production, capture and reuse waste generated and deliver environmental sustainability with due regard to food safety implications (Linked to Action 12).
- Research is needed into peat replacement alternatives/technology to reduce or eliminate peat usage in the Horticulture sector.
- Explore alternative protein crops for human use. This would capitalise on the increasing trend of plant-based diets.
- Increase energy efficiency and the deployment of renewable energy, such as the use of biomass, wind energy and solar photovoltaics to power horticulture production units, machines, equipment etc. (Linked to Action 18).

Bioeconomy

The finite biological resources and ecosystems of our planet are essential to feed people, provide healthy soils, clean water and affordable and sustainable energy. A sustainable bioeconomy is essential to tackle climate change, land and ecosystem degradation and reduce our dependence on non-renewable resources. Deploying a sustainable and circular bioeconomy will boost the competitiveness of the bioeconomy sectors (i.e. agri-food, forestry, marine) and support the creation of new value chains across rural, regional and urban areas while enhancing the overall status of our natural resources. An Irish bioeconomy will rely and capitalise on domestically available sustainable renewable resources, and on advances in sciences, technologies and innovations merging the physical, digital and biological worlds, in Ireland's agri-food and bio-based sectors and industries.

Action 12: Promote the development of a sustainable circular bioeconomy within the agri-food sector

- Support the development of the sustainable circular bioeconomy ensuring resource efficiency and developing circularity by addressing issues such as pasture valorisation, food and organic waste and losses, by-product valorisation, nutrient recycling, water recycling and recycling of plastics. Strategic actions should support and promote all types of innovations and practices for sustainable food and farming systems, forestry and bio-based production through systemic and cross-cutting approaches linking actors, territories, sectors and value chains.

Action 13: Explore all options in relation to land use diversification

- Engage with Teagasc, the National Economic and Social Council (NESC) and other stakeholders to review and analyse the full suite of land diversification options to consider alternative economic opportunities that could assist with a just transition to lower emissions land use options, ranging from horticultural production, protein crop production, organic farming, energy crop production to afforestation and agroforestry.
- Support supply chain development where new market opportunities need support e.g. new business models, development of critical size, agronomy or processing technologies etc.

Enhance the development of sustainable land management practices by delivering 26.8 Mt CO₂eq abatement through LULUCF actions over the period 2021 to 2030.

Actions required to meet this ambition

Forestry

A key requirement for the sector is to deliver additional CO₂ abatement by 2030. Forestry, undoubtedly, is a big component of this land use change and provides a range of multiple benefits and ecosystem services. All farmers, where practical, should give serious consideration to planting a part of their holding with trees. Woodlands not only sequester carbon dioxide from the atmosphere but also store carbon in the timber produced and can replace materials made from non-renewable resources. Forest biomass can also play an important role in bioenergy replacing fossil fuels and reducing overall emissions in the energy sector. Farmers planting forests will benefit from their positive action by receiving

funding in the form of grants and premiums and in the multiple social and environmental benefits that trees provide.

Action 14: Increase afforestation levels and maximise the contribution of existing forests to climate change mitigation and adaptation

- Increase afforestation levels to 8,000 ha per year.
- Encourage the planting of a range of different species to ensure forests are adaptive and resilient to the impacts of climate change.
- Construct 125 km of new forest roads per year to facilitate the mobilisation of biomass and harvested wood products, encouraging the transition to a low carbon economy.
- Increase the area of conifer and broadleaved planting nationally and encourage a mix of species to provide a range of multiple benefits such as timber, shelter, landscape and biodiversity.
- Expand the areas of broadleaved and native woodland planted nationally through initiatives such as the;
 - Native Woodland Scheme
 - Woodland Environmental Fund
 - Afforestation Scheme –broadleaved measures
 - Agro forestry
- Continue to fund through the forestry programme the planting of woodlands of different sizes from 0.1 ha upwards to increase connectivity between hedgerows, larger woodlands and provide corridors for wildlife. All landowners should have the capacity to plant some of their farm with trees, from small corners, to shelters belts to larger more commercial size forests. This will be achieved by closer integration between the schemes under the next round of CAP and the next national Forestry Programme.
- Examine publically owned lands to determine the availability of lands for afforestation.
- Examine the potential for approximately 1,500 ha of native woodland afforestation on a small part of the industrial cutaway bogs to complement Bord na Mona's rehabilitation strategy to provide a mosaic of freshwater and terrestrial habitats for biodiversity.
- Encourage the diversification of different types of forestry systems such as agroforestry and continuous cover forestry.
- Continue to fund knowledge transfer groups promoting sustainable forest management.

- Protect, maintain and support the development of Ireland's existing forest estate and reduce deforestation.
- Examine new opportunities for the forestry sector through the replacement of unsustainable raw materials in construction and packaging with bio-based materials, polymers, fibres and composites and for providing more sustainable innovations in sectors such as forestry-based textiles, furniture and chemicals, and new business models based on the valuation of forestry ecosystem services (Linked to Action 12).

Carbon Pools in the Agricultural Landscape

Ireland has an abundance of mineral soils under grassland and research indicates that livestock, sward and nutrient management can be optimised to maximise carbon sequestration in mineral soils. As change occurs over many decades before an equilibrium position is reached, it is difficult to accurately measure soil carbon stock changes in soils. However, technology is available to assist in these measurements.

Currently, based on tier 1 emission factors, Irish grasslands are a net source of CO₂ due to emissions from permanent grassland on drained carbon rich soils. There is an estimated 300,000ha of permanent grassland on drained carbon rich soils where the carbon pool is very vulnerable, especially when drained. Soils with high organic matter, when drained, allow additional air into the soil to break down the organic matter releasing CO₂ into the atmosphere. Reducing emissions by water table manipulation and reduced management intensity has the potential to, not only significantly reduce GHG emissions from these soils, but also to improve water quality, increase biodiversity and to improve resilience and adaptation to changing weather patterns.

However, the level of farming intensity that can be sustained post water table manipulation is farm- and site-specific. Assessment of best practice management options for optimum environmental and production outcomes requires research. Capturing impacts from changes in management and developing associated emission factors will be challenging and will require the establishment of long-term monitoring sites.

In order to fully capitalise on the opportunities for Irish grasslands and carbon sequestration, the issue of carbon losses from organic soils must be addressed. It is proposed to address this issue in Action 15 below. As a parallel process, research funds must be committed to the carbon sequestration potential of mineral grasslands soils and this is referenced in Action 24.

Hedgerows provide another important carbon pool in the landscape and they also act as an important habitat for biodiversity. However, there is no national inventory system, let alone a farm level system to facilitate the accounting of hedgerow sinks given the lack of historic baseline data to be used as a reference period for calculating greenhouse gas changes over

time. Hedgerows in terms of the above and below surface biomass need to be measured through a focused survey of representative hedgerow types and through actions of digging up/burning to provide estimates. Further work now needs to be done to maximise the biodiversity and climate benefits of the national hedgerow resource.

Carbon farming refers to the farm-level management of carbon pools and flows with the purpose of mitigating against climate change. Result-based carbon farming schemes require that a direct and explicit link is established between the results delivered (e.g. GHG emissions avoided or CO₂ sequestered) and the payments made to the land manager. These schemes offer opportunities to better incentivise farmers to undertake climate-friendly actions.

Action 15: Reduce the management intensity of at least 40,000ha of peat based agricultural soils to reduce CO₂ loss

- Identify grasslands on carbon rich soils (and determine their drainage status) that are suitable for water table management to reduce carbon losses.
- Implement a pilot scheme on reduced management intensity to serve as “proof of concept” for scaling up to a larger agri-environmental scheme.

Action 16: Protect, enhance, and increase the number of hedgerows on farms

- Protect and enhance the current hedgerow resource on Irish farms by increased awareness of Good Agricultural and Environmental Condition (GAEC).
- The Department to collaborate with local authorities to revisit and complete the county-based hedgerow surveys.
- Examine the scope to plant trees in conjunction with hedgerows to improve landscapes and shelter, particularly those farm holdings that have no trees currently planted (Linked to Action 14).

Action 17: Develop a pilot scheme in relation to on-farm carbon trading to reward farmers for the public goods they are providing

- Many extensively stocked livestock farms on mineral soils, with extensive hedgerows, will have a very small carbon footprint. These farmers should be rewarded for the public goods they are providing as they align to Origin Green marketing credentials. This will incentivise these farmers to retain and protect these goods.
- Work with other Member States and the European Commission to consider the development of a regulatory system for carbon farming which ensures a level playing field across the EU.

Contribute to sustainable energy and decarbonisation of energy system

It is recognised that the agriculture sector has a key role to play in helping Ireland meet its energy efficiency and renewable energy targets. In addition, adoption of energy efficiency and renewable technology generation can enhance the green image of the agri-food sector both nationally and globally.

In the short term, based on the technologies that are currently readily available, there is an opportunity for the sector to contribute by using energy more efficiently and becoming more self-sufficient in terms of renewable energy production. Currently the adoption rates of energy efficiency measures on farms varies considerably and in some instances are quite low. Similarly the generation of renewable energy for self-consumption is also quite low at less than 1%.

In the medium to long term, increasing the provision of bioenergy feedstocks, including forest thinning, animal by-products such as residues from meat processing and slurries, and energy crops such as grass silage will be an important part in the renewable energy mix for Ireland, all playing a role in the displacement of fossil fuels. Removing forest thinnings, which can then be used to displace fossil fuels, allows the remaining trees to increase in diameter and when harvested in the future provides long term carbon storage in harvested wood products. Other forest biomass such as brush and low diameter materials not suitable for harvested wood products can also provide material for bioenergy. The use of bioenergy feedstocks will be influenced by policy developments such as the Renewable Electricity Support Scheme (RESS), the Support Scheme for Renewable Heat (SSRH) and the Biofuels Obligation Scheme. The agriculture sector has a key role to play in the provision for bioenergy feedstocks for the production of biogas/ biomethane as a key renewable energy resource for the decarbonisation of the transport and heat sectors in particular.

Action 18: Generate at least a 20% reduction in agricultural energy use by 2030 across all farms. In addition, generate at least 20% deployment of renewable energy technologies focusing primarily on energy intensive farming systems

- Review the terms and conditions of all the Department's programmes that support sustainable energy to maximise the uptake of energy efficiency and renewable energy deployment at farm-level.
- Increase awareness of the benefits of energy efficiency and deployment of renewable technologies at farms working in partnership with Teagasc, SEAI and other key stakeholders.
- Collaborate with the Department of Environment, Climate and Communications (DECC) to ensure the enabling framework for microgeneration facilitates

opportunities for the agri-sector and rural communities to contribute to decarbonisation of the economy and society.

Action 19: Double the sustainable production of biomass from forests by 2030 and ensure biomass mobilisation for heat production

- Enable increased access into forests to allow for efficient and timely harvest of timber for delivery to the market.
- Displace approximately 2 Mt CO₂ eq in greenhouse gas emissions from fossil fuels through the use of forest-based biomass not suitable for harvested wood products.
- Explore new opportunities for the forestry sector through the replacement of unsustainable raw materials in construction and packaging with bio-based materials, polymers, fibres and composites (Linked to Action 14).

Action 20: Engage with stakeholders to maximise the potential opportunities from Anaerobic Digestion for the agriculture sector

- Work closely with DCCAE and other key stakeholders to set a target for the level of energy to be supplied by indigenous biomethane injection and consider the necessary supports including funding mechanisms.
- Work with DCCAE and other stakeholders to develop the necessary research, policies and measures to provide policy certainty around the development of an Anaerobic Digestion industry in Ireland.

Work in partnership with co-operatives, farmers and representative bodies to develop governance structures and business models to ensure that the maximum benefit through Anaerobic Digestion is realised while also contributing significantly to the decarbonisation of Ireland's agriculture system.

Cross cutting enabling actions into the future

Agricultural Knowledge and Innovation Systems (AKIS)

In order to fully implement many of the actions in this roadmap, the sector will need a functioning, adaptable and inclusive AKIS strategic development, currently being discussed under the CAP reform. Ireland is uniquely placed to deliver on this action, given that Teagasc is one of the few organisations globally to have research, education and extension operations under its remit.

Teagasc will be central to this strategic development where the focus will be on:

1. Enhancing knowledge flows and strengthening links between research and practice;

2. Strengthening all farm advisory services and fostering their interconnection within the AKIS;
3. Enhancing cross-thematic and cross-border interactive innovation; and
4. Supporting the digital transition in agriculture.

Farm advisors, both public and private, will need continued professional development to ensure that a consistent message, based on the latest scientific information, is shared with our farmers. Further research and innovation investment is needed in many areas. This is the basis of the following actions.

Action 21: Undertake AKIS strategic development

- This strategic development will include the development of measures to address key challenges such as the development of: cross thematic approaches including the use of decision support tools and performance metrics to underpin implementation of the GHG and ammonia MACCs; improving soil fertility and reduced fertiliser use through more effective soil, grassland and nutrient management and; promoting the transition from CAN to protected urea and optimising the use of livestock manure and biological N fixation.
- Promote investment in the innovation strand of the Common Agricultural Policy (CAP) network to share all recent innovative knowledge created in National and European innovation and research projects. Knowledge and experiences should be developed, tested and shared through focus groups, networking, knowledge exchange groups, living labs, communities of practice, incubators, specialist hubs and cooperation and co-operative activities.

Action 22: Develop a continued professional development strategy for all advisors

All advisors, within Teagasc, the private network, and those based in industry should undergo appropriate training on an ongoing basis. In recent times, Teagasc has successfully rolled out their online ConnectED training programme to provide access to knowledge and the latest research which is crucial to achieving sustainable development within the agri-food sector.

- Through integration and interaction within the AKIS system, empower advisors to give advice on economic, environmental and social dimensions and to deliver up to date technological and scientific information developed by research and innovation.
- Develop advisors' competences to take up a more interactive role and serve as innovation brokers and to support services including helping to discover farmers' needs and to prepare and facilitate innovative cooperative activities and cooperation projects (e.g. EIP Operational Groups, LEADER projects).

Action 23: Establish a network of Sign-Post Farms

- Teagasc and the wider industry to develop a network of demonstration 'sign-post' farms to underpin confidence, behavioural change and provide on farm experience of the benefits of embracing climate action and sustainable energy, including sustainable adaptation measures. These farms will play a crucial role in the peer to peer dissemination of the MACC measures and the actions in this roadmap.

Action 24: Establish a Centre of Excellence to ensure Ireland as a global leader in research and innovation related to climate smart agriculture and land use

- Establish world class expertise in ruminant methane emissions within grazing systems. Ireland should position itself as a global leader in this space given the importance of ruminant livestock to the Irish agri-food sector. Significant emphasis should be placed on novel feed additives that could contribute to a reduction in biogenic methane, something that will be required between now and 2050.
- Establish expertise in grassland soil carbon fluxes. Ireland has an abundance of mineral soils, which with appropriate management could sequester significant quantities of carbon from the atmosphere. While accounting rules are set out to 2030, grassland sequestration offers significant offsetting potential in the period 2030 and beyond. With this in mind, infrastructural investment into a series of monitoring towers for the verification of CO₂ emissions /removals from peat and mineral soils is required.
- Continue to invest in research and innovation, both within Teagasc and other higher education institutes. Some elements of the Teagasc GHG MACC require further research e.g. management of grass clover swards, the benefits of mixed species swards, better utilisation of nitrogen in grassland systems, and sexed semen breeding technology as well as research to identify and develop new abatement measures.
- Develop research for carbon-neutral resilient farms: undertake an interdisciplinary programme of work targeting an integrated approach to farm planning and management; soil health and grassland management; animal diet and breeding; inputs; biodiversity; circularity; ICT; life-cycle analysis and renewable bio-based products and energy; and business models taking a holistic view of the farm/farms to reduce greenhouse gas emissions and increase the health and resilience of the farm.
- Develop strategic international partnerships including with other EU Member States, countries beyond the EU with a focus on addressing agriculture and climate action and also innovation organisations such as EIT Climate-KIC who are a Knowledge and Innovation Community (KIC) funded by the EU Commission, working to accelerate the transition to a zero-carbon economy.

Action 25: Develop an Information Portal relating to the actions of this roadmap

- Bord Bia and Teagasc are developing an online interface to support Farm Sustainability Plans agreed between Teagasc advisors and their clients. This will be supported via an online information portal, which would act as a “one stop shop” for all the background information relating to the actions in this roadmap.

Origin Green and Quality Assurance Schemes

Established by Bord Bia in 2012, the purpose of Origin Green is to drive and monitor positive change across Ireland's food and drink industry in order to build and protect our global reputation for food sustainability. In light of increasing environmental, policy and market pressures, Even greater evidence of sustainability credentials are now required in the marketplace. Bord Bia will work in collaboration with industry partners to leverage its programmes and supports such the Sustainable Assurance framework and the Origin Green charter to achieve the national climate reduction objectives.

Strengthening our reputation through credible, measurable actions is a key lever to drive competitive advantage and sustained growth for Irish food and drinks manufacturers and farmers.

Action 26: Bord Bia to develop a roadmap of initiatives in partnership with industry to support farmers to achieve market demands, including:

- The Department, Teagasc, Bord Bia and Industry will revise Origin Green's quality assurance schemes to develop / evolve in line with best practice advice which will support farmers in delivering verifiable market driven sustainability.
- The 'Carbon Navigator' is a unique farm advisory tool used to guide farmers in their application of basic sustainability principles on their own farms. The Carbon Navigator tool should be further developed in conjunction with Teagasc to incorporate additional measures and should be promoted by all stakeholders to implement scalable change on farms.
- The online platform referred to in Action 25 should display the Origin Green Farmer Feedback Reports and Farm Sustainability Plans maximising the linkages between Quality Assurance Scheme outputs and farm advisory services.
- Consideration should be given to including membership of Bord Bia Sustainable Assurance schemes as an eligibility requirement for appropriate the Department funded schemes.

Expert Consultative Groups

Many of the actions identified in this roadmap are clear and action on the implementation side can begin immediately. For other actions, and in order to achieve progress by 2030, expert consultative groups will be established in order to chart a clear path for delivery. Where appropriate, the target date for the establishment of all groups is summer 2021.

Funding

The next CAP will have an increased focus on climate action and the environment. This will provide opportunities to develop new tailored schemes to enable farmers to make the just transition that is required. However, the new CAP has been delayed and it is not expected to commence until 2023. In the interim period, the Rural Development Programme will continue to support the delivery of targets. It is also proposed to conduct pilot measures over the period with a view to scaling these in 2023 to further support the delivery of our climate targets.

However, it is clear, given the scale of the challenge, that the broader agri-food industry will need to be more proactive in supporting farmers, through incentives and collaboration, to make the appropriate changes over the next decade.

Action 27: Review the Rural Development Programme (2014-2020) and consider national fiscal policy instruments to ensure further supports for our climate targets

- Review of all current RDP Schemes in 2021 in order to increase environmental and climate ambition to support the actions outlined in this roadmap.
- Consider further national fiscal policy instruments to support the actions in this roadmap.

Action 28: Ireland Strategic Investment Fund (ISIF)/Enterprise Ireland (EI) innovation (climate smart agriculture/smart farming) fund

- Develop an ISIF/EI Innovation (climate smart agriculture/smart farming) fund to proactively support adoption of innovation and appropriate technologies/practices that reduce absolute environment footprint of agriculture further underpinning grass ultimate selling point (USP), crop diversification opportunities etc.

Just transition

Policies implemented to achieve emissions reductions and enhance carbon removals may have social implications that need to be addressed for just transition.

Action 29: Establish a 'Future of Farming in Ireland Dialogue', which will include farmers, scientists, environmentalists and social groups to find practical solutions for productive, sustainable agriculture

- This dialogue could also facilitate evaluation of progress on climate action and biodiversity and facilitate an information campaign for better appreciation of agriculture and land use by the non-farm community.

Summary

Ireland faces significant challenges to meeting its climate change and air quality targets (as well as biodiversity and water quality targets). This challenge is replicated across all other sectors of the economy including transport and energy.

If Ireland wishes to remain a world leader in the production, management and marketing of low-carbon, high-quality sustainable and traceable food, then significant efforts will be required on a whole of government, whole of sector basis to maximise production efficiency whilst minimising the effects on the climate and reducing the environmental footprint of agriculture. There is no doubt that Ireland has a fantastic story to tell in the international marketplace. Nevertheless, the rapid expansion of the dairy sector is pushing environmental boundaries in some catchments, including increasing GHG and ammonia emissions. This needs to be addressed building on initiatives such as Dairy Sustainability Ireland and the Agricultural Sustainability Support and Advisory Programme (ASSAP).

Failure to implement changes today will mean that more radical corrective action will be necessary later to ensure delivery of our commitments. Scientific research and innovation, the acceleration of the adoption of best practices at farm level and working in partnership, across the entire agri-food sector, will be a critical success factor in striving towards our vision of climate neutrality.

By working together, the sector can ensure its long-term sustainability, from an economic, social and environmental perspective, thus safeguarding the Irish family farm for generations to come.

