

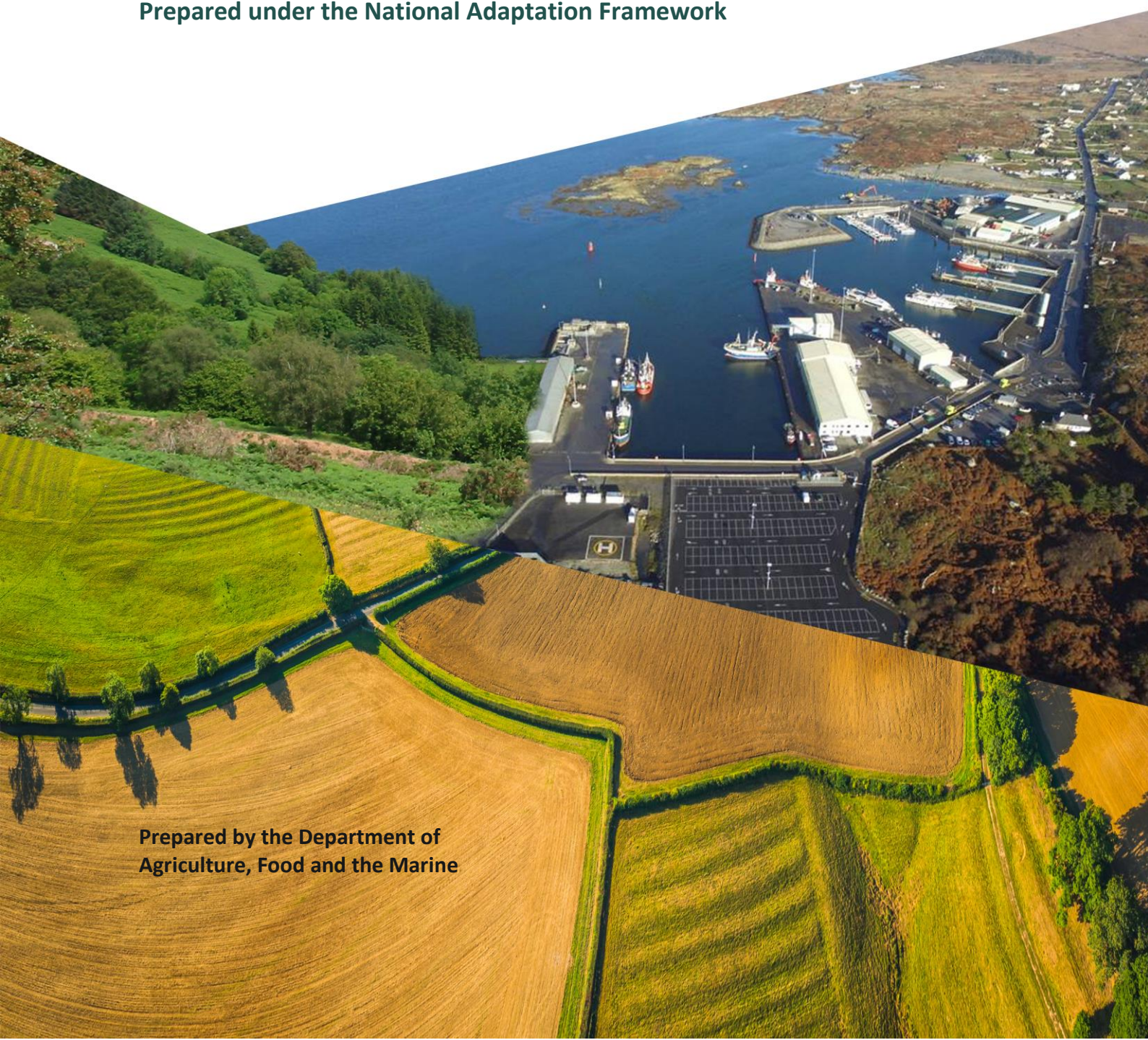


**Rialtas na hÉireann**  
Government of Ireland

# Agriculture, Forest and Seafood

## Climate Change Sectoral Adaptation Plan

Prepared under the National Adaptation Framework



Prepared by the Department of  
Agriculture, Food and the Marine

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## Foreword

I welcome the publication of the Department's first statutory Adaptation Plan for the agriculture, forest and seafood sector. This Plan builds on the baseline work undertaken by my Department in preparation of the Adaptation Planning document published in 2017.

Adaptation and mitigation are both essential elements in addressing climate change. Therefore, we are taking a holistic approach to climate action. While we have two separate plans, one setting out the steps we will take to mitigate climate change and this Plan which deals with adaptation, both plans are part of our overall approach for dealing with climate change and will be integrated into the everyday work of the Department.

The agriculture, forest and seafood sector is heavily impacted by the weather, therefore, it is important that we are ready to deal with future changes in our climate. Any risk to the sustainability of our food production poses serious concerns. A continued and intensified focus on climate action measures, including adaptation, will be central to the continuation of a sustainable supply of food both from the land and our seas. We have a sustainable agri-food sector which must be protected.

We have seen evidence in recent times of a greater awareness across society of the need to take actions to reduce emissions of the greenhouse gases that are driving climate change. However, we know that our climate is changing and will continue to change due to the historic levels of carbon dioxide in the atmosphere meaning that we will have no choice but to adapt.

This Plan sets out the projected changes in climate focussing on those identified as most likely to impact the agriculture, forest and seafood sector. A list of priority risks and possible consequences has also been identified.

Building resilience and adapting to expected climate change in the agriculture, forest and seafood sector represents a unique challenge when compared to many other sectors in that it will require buy-in and behavioural change from a number of individual producers and those involved in food supply chains. With this in mind, we have taken a case study approach to highlight some real examples of where the sector has been impacted by weather events, what the future projections are saying and how we could see similar such events, with a focus on building resilience.

This Plan is the first of many under the National Adaptation Framework. I hope that the information contained in this document sheds some light on the steps we need to take to build a strong and resilient agriculture, forest and seafood sector that is well placed to take on the challenges and opportunities presented by our changing climate.

Michael Creed, T.D.

Minister for Agriculture, Food and the Marine



## 1. Introduction

The *Climate Action and Low Carbon Development Act 2015* provides the statutory basis for the national objective to transition to a low carbon and climate-resilient economy by 2050. Under the Act the Minister for Communications, Climate Action and Environment must make and submit to Government a series of successive National Mitigation Plans and National Adaptation Frameworks.

Ireland's first Statutory *National Adaptation Framework (NAF)*<sup>1</sup> was published in 2018 and sets out the national strategy to reduce the vulnerability of the country to the negative effects of climate change and to avail of any positive impacts. Twelve key sectors were identified and are required to prepare sectoral adaptation plans. The Department of Agriculture, Food and the Marine is responsible for three of those sectors – Agriculture, Forest and Seafood. This Plan which covers the agriculture, forest and seafood sectors has been prepared in line with the *Sectoral Planning Guidelines for Climate Change Adaptation*.

Engagement of citizens, business and communities is an essential part of ensuring positive climate action. This type of inclusive policy development has been acknowledged by the Joint Oireachtas Committee on Climate Action in their Report and by the Government as part of the all of Government Climate Action Plan. Public consultations, such as the consultation on Climate Change Adaptation completed in the preparation of this Plan, are imperative in not only informing citizens about the likely impacts of climate change but also in engaging with citizens and empowering citizens to contribute to the transition ahead. This Plan has been updated to reflect issues raised in submissions received as part of the public consultation process.

### Link to the Sustainable Development Goals

The 2030 Agenda for Sustainable Development, *Transforming Our World*<sup>2</sup>, which was adopted by Ireland in 2015 aims to deliver a more sustainable, prosperous and peaceful future for the entire world. It sets out a framework for how to achieve this comprising 17 Sustainable Development Goals (SDGs). Ireland's *National Implementation Plan 2018-2020*<sup>3</sup> further details how the SDGs will be implemented to support national policy. Goal 13: *Climate Action* is particularly relevant to this Plan as it aims to strengthen resilience and adaptive capacity; integrate climate change measures into national policy and measures; raise awareness and educate which are reflected in the objectives of this adaptation Plan.



<sup>1</sup> <https://www.dccae.gov.ie/documents/National%20Adaptation%20Framework.pdf>

<sup>2</sup> [https://www.unfpa.org/sites/default/files/resource-pdf/Resolution\\_A\\_RES\\_70\\_1\\_EN.pdf](https://www.unfpa.org/sites/default/files/resource-pdf/Resolution_A_RES_70_1_EN.pdf)

<sup>3</sup> <https://www.dccae.gov.ie/documents/DCCAE-National-Implement-Plan.pdf>



### ***Non-Statutory Plan***

The Department published a non-statutory adaptation planning document in 2017 titled, *'Adaptation Planning – Developing Resilience to Climate Change in the Irish Agriculture and Forest Sector'*. This document was the first attempt at raising awareness of the climate adaptation issues arising in the Irish agriculture and forest sector and attempted to start a conversation around building resilience in the sector. An impact and vulnerability assessment was undertaken as part of that process which provided excellent baseline data for the current Plan. We have built on the work and experiences gained as part of that process to shape our current plan.

At the outset the main difference this time around is the inclusion of the seafood sector<sup>4</sup> as part of the Plan, thereby taking a whole of department approach to adaptation planning. We also sought to better align our Plan with the goals and objectives identified in the Department's Statement of Strategy.



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<sup>4</sup> The Seafood Sector to which this draft plan applies comprises Sea-Fisheries, Aquaculture, Fishery Harbours and Coastal Infrastructure for the Seafood Industry. In addition, the Minister is responsible for a wide range of Marine Research conducted by the Marine Institute through the management of expenditure under the Department's vote.

Efforts have been made to prepare a more accessible document using case studies (**APPENDIX I**) to show real examples of the impact of future climate change projections on the sector and some of the steps which could be taken towards building resilience to deal with these impacts. It is hoped that by using case studies we can improve understanding and encourage discussion on the potential impact of climate change on the sector. By taking steps to reduce exposure to present climate variability we can inform future climate adaptation requirements and increase resilience.

Figure 1 below highlights National Climate Policy development and the linkages with sectoral adaptation plans.

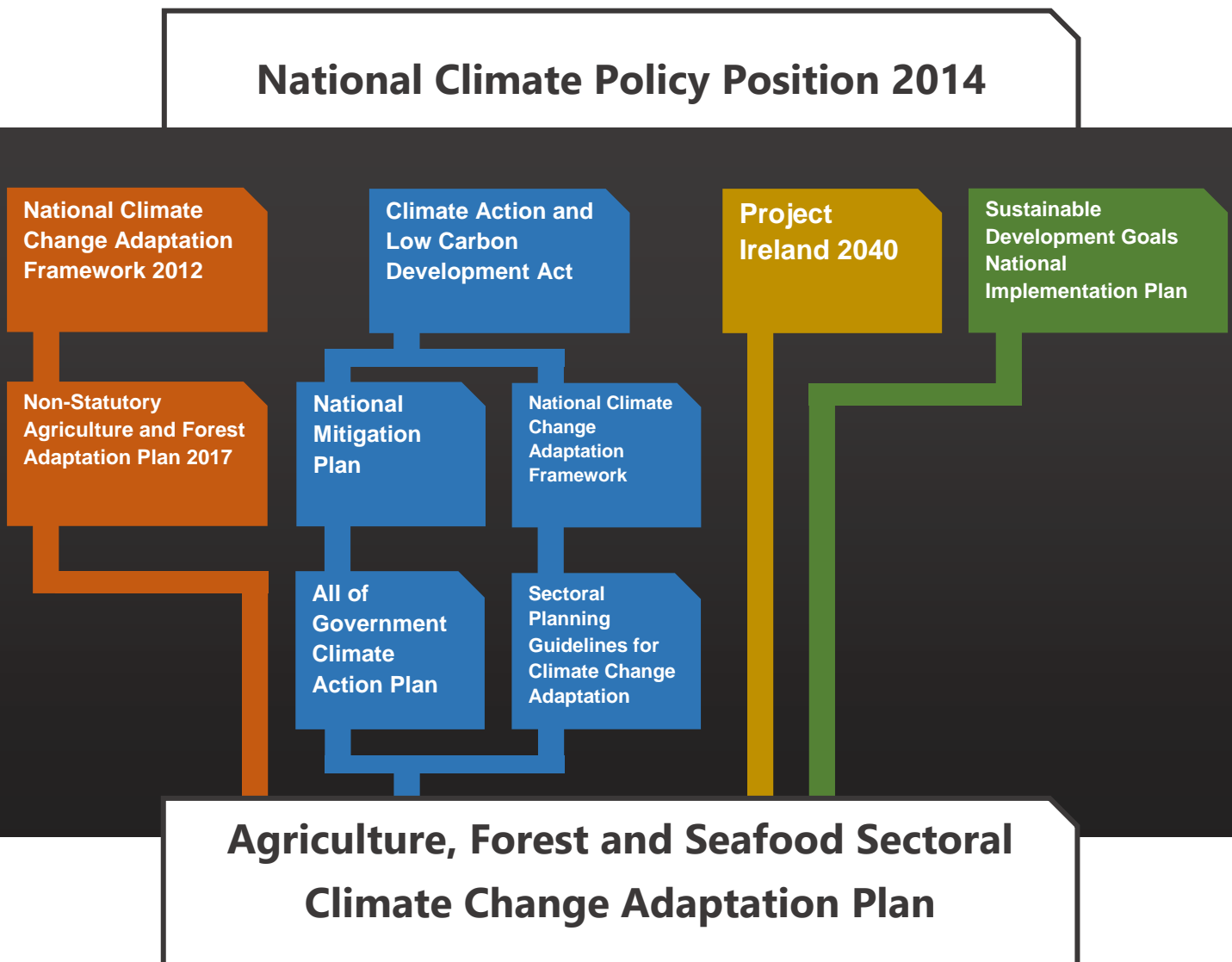


Figure 1: Hierarchy of National Climate Policy and sectoral adaptation plans development

## 2. Adaptation Plan Goal and Objectives

### **Overall Adaptation Goal**

*Build resilience to the effects of climate change and weather related events in the agriculture, forest and seafood sector, reduce any negative impacts where possible, take advantage of any opportunities and to contribute to achievement of DAFM Statement of Strategy Goals.*

#### **Four overarching Objectives**

1. Ensure a joined up approach to adaptation planning in the Department of Agriculture, Food and the Marine
2. Raise awareness of the impacts of climate change in the agriculture, forest and seafood sector
3. Reduce vulnerability of the agriculture, forest and seafood sector to main climate impacts and seek to increase resilience
4. Embed adaptation planning in agriculture, forest and seafood sectoral policies

*Planned adaptation aims to create more climate resilient communities and food systems by taking proactive steps to prepare for the impacts of projected climate change.*

### **Alignment with DAFM Statement of Strategy Strategic Goals**

#### **Food Safety, Animal and Plant Health and Animal Welfare.**

**To promote and safeguard public, animal and plant health and animal welfare for the benefit of consumers, producers and wider society**

#### **Policy and Strategy.**

**Provide the optimum policy framework for the sustainable development of the agri-food<sup>5</sup> sector**

#### **Seafood Sector.**

**Deliver a sustainable, growth driven sector focused on competitiveness and innovation driven by a skilled workforce delivering value added products in line with market demands**

<sup>5</sup> Agri-food encompasses everything from primary agriculture to food and beverage production, from fisheries and fish processing to forest and forest outputs.

## Box 1: Mitigation and Adaptation Interactions

### What do we mean by “adaptation”?

Adaptation is the process of adjustment to actual or expected climate stimuli (changes in mean climate and climatic hazards) and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities.

### What are adaptation actions?

Adaptation actions aim to reduce the impacts of climate change and also to take advantage of any opportunities presented by climate change.

### What do we mean by “mitigation”?

Mitigation is a human intervention to reduce the sources or enhance the sinks of greenhouse gases.

### What are mitigation actions?

Mitigation actions focus on limiting the rate and scale of future climate change by reducing levels of greenhouse gas emissions and increasing GHG sinks.

### Integration of mitigation and adaptation

In the agriculture, forest and seafood sector, adaptation and mitigation are more integrated than in other sectors, therefore these actions can and should work in an integrated manner to maximise co-benefits and to decrease the impacts of climate change on rural and coastal livelihoods and enhance the resilience of our food, fibre and fuel production systems.



### 3. Climate Change Trends in Ireland

The dominant influence on Ireland's climate is the Atlantic Ocean. Consequently, Ireland does not suffer from the extremes of temperature experienced by many other countries at similar latitude. The warm North Atlantic Drift has a marked influence on sea temperatures. This maritime influence is strongest near the Atlantic coasts and decreases with distance inland. The hills and mountains, many of which are near the coasts, provide shelter from strong winds and from the direct oceanic influence. Winters tend to be cool and windy, while summers, when the depression track is further north and depressions less deep, are mostly mild and less windy<sup>6</sup>.

#### 3.1 What is Climate Change?

Climate change refers to long-term changes in the earth's weather patterns or average temperature.

#### Changing Irish Climate

An Environmental Protection Agency (EPA) report titled, '*Status of Ireland's Climate 2012*' has analysed meteorological records and the results show that Ireland's climate is changing in line with global patterns<sup>7</sup>. This report also highlights the state of Ireland's climate based on the collation and analysis of over 40 different variables observed in the atmospheric, oceanic and terrestrial environments. Some changes which have influenced the agriculture and forest sector are included in Box 2.

#### Box 2: Changes which have influenced the agriculture and forest sector

- The mean annual surface air temperature has increased by approximately 0.8oC over the last 110 years. The number of annual frost days (temperatures below 0 degrees Celsius) has decreased whilst the number of warm days (temperatures over 20 degrees Celsius) has increased.
- Average annual national rainfall has increased by approximately 60mm or 5 per cent in the period 1981 to 2010, compared to the 30-year period 1961 to 1990. In general, the larger increases are observed over the west of the country. However, clear changes in rainfall spatial patterns across the country cannot be determined with a high level of confidence.
- Observations of the timing of bud-burst for a number of tree species at the International Phenological Gardens indicate that the beginning of the growing season is now occurring more than a week earlier than in the 1970s, leading to an extension of the growing season. Such changes have been linked to a rise in average spring air temperature.

<sup>6</sup> <https://www.met.ie/climate> accessed 19.02.2019

<sup>7</sup> <http://www.epa.ie/pubs/reports/research/climate/CCRP26%20-%20Status%20of%20Ireland%27s%20Climate%202012.pdf>

The last comprehensive analysis of observational indicators of change in the marine climate and ecosystems were the 'Irish Ocean Climate and Ecosystem Report 2009'<sup>8</sup> and the 'Status of Ireland's Climate 2012', which outlined the headline changes in Box 3.

### Box 3: Headline changes in the Irish Ocean climate and ecosystems

- Increase in sea surface temperature of 0.6°C per decade since 1994 is unprecedented in the past 150 years.
- Increase in wave heights of 0.8 m off southwest Ireland.
- Satellite observations indicate that the sea level around Ireland has risen by approximately 4–6 cm since the early 1990s.
- Ocean acidity has increased significantly in sub-surface and deep offshore waters around Ireland between 1991 and 2010.
- Phytoplankton - Increased numbers of diatoms and dinoflagellates around the Irish coast since 1998.
- Increase in warm water *Calanus spp* and gelatinous zooplankton species in recent years.
- Increased numbers of most warm water marine fish species in Irish waters with increased sightings of exotic fish species.
- Decline in salmon, trout and eel populations since the 1980s, in which climate and ocean change may have had a role.

While the analysis to date has been considerable the brevity of some of the time series means that on a national level we are relatively poorly equipped to make conclusions as to how climate change is affecting and will continue to affect Irish waters, ecosystems and the services that rely upon them.

### 3.2 What will Ireland's future climate look like?

While climate change impacts are projected to increase in the coming decades and during the rest of this century, uncertainties remain about the scale and extent of these impacts, particularly during the second half of the century. These uncertainties exist due in part to the inherent variability and chaotic nature of the climate system. The EPA Reports, 'A Summary of the State of Knowledge on Climate Change Impacts for Ireland,' and 'Ensemble of Regional Climate Model Projections for Ireland'<sup>9</sup> together provide an outline of the regional climate modelling undertaken to determine the potential impacts of climate change in Ireland, based on a number of possible future scenarios. The

<sup>8</sup> <https://oar.marine.ie/handle/10793/81> accessed 08.04.2019

<sup>9</sup> [https://www.epa.ie/pubs/reports/research/climate/EPA%20159\\_Ensemble%20of%20regional%20climate%20model%20projections%20for%20Ireland.pdf](https://www.epa.ie/pubs/reports/research/climate/EPA%20159_Ensemble%20of%20regional%20climate%20model%20projections%20for%20Ireland.pdf)

latter Report by Nolan on the future climate of Ireland was simulated at high spatial resolution for the 40-year period 2021-2060. For reference, the past climate was simulated for the period 1961-2005. The difference between the two periods provides a measure of climate change. Findings from this study are indicated in the tables below.

In terms of future climate changes for Irish waters, indications from the Met Éireann and University College Dublin report in 2008 titled *'Ireland in a Warmer World'*<sup>10</sup>, and Met Éireann's report, *'Ireland's climate: the road ahead'*<sup>11</sup> are also provided in the following table.

In particular the "medium-to-low" and "high emission" ensemble from Nolan's work were used when assessing the vulnerability and impact on the agriculture, forest and seafood sector.

| Variable                                     | Mid Century Impacts   |
|--|---|
| Changes in air temp                          | <ul style="list-style-type: none"> <li>• Mean annual temperatures will increase by 1–1.6°C, with the largest increases seen in the east of the country.</li> <li>• Hot days will get warmer by 0.7–2.6°C compared with the baseline period.</li> <li>• Cold nights will get warmer by 1.1–3.1°C.</li> <li>• Averaged over the whole country, the number of frost days is projected to decrease by over 50%.</li> <li>• The average length of the growing season will increase by over 35 days per year.</li> </ul>              |
| Changed precipitation patterns and hydrology | <ul style="list-style-type: none"> <li>• Significant decreases in rainfall during the spring and summer months are likely leading to increased chances of drought conditions.</li> <li>• Heavy rainfall events will increase in winter and autumn.</li> </ul>   |
| Extreme events                               | <ul style="list-style-type: none"> <li>• The energy content of the wind is projected to decrease during spring, summer and autumn. The projected decreases are largest for summer, with values ranging from 3% to 15%.</li> <li>• Storms affecting Ireland will decrease in frequency, but increase in intensity, with increased risk of damage.</li> <li>• Increase in the frequency of storm surge events around Irish coastal areas.</li> <li>• Extreme wave heights are also likely to increase in most regions.</li> </ul> |
| Changes in ocean temp                        | <ul style="list-style-type: none"> <li>• Continued warming of Irish water consistent with global ocean projections.</li> <li>• Changes in freshwater temperatures, dissolved oxygen and river flows with possible negative consequences for fish growth and survival and knock-on impacts in estuaries.</li> </ul>  |
| Sea Level                                    | <ul style="list-style-type: none"> <li>• Sea levels will continue to rise in line with global projections.</li> </ul>   |

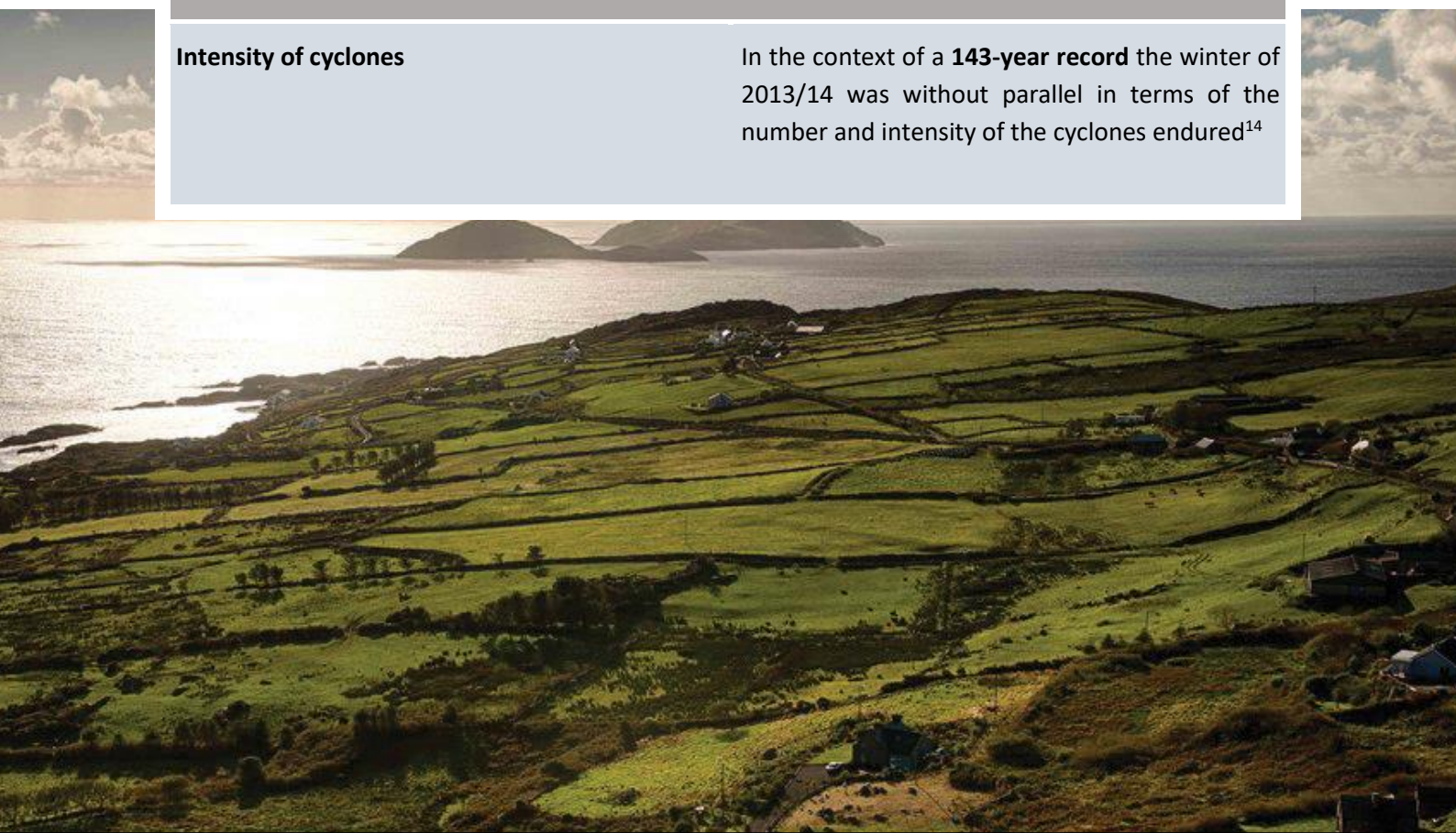
<sup>10</sup> [https://maths.ucd.ie/~plynch/Publications/Ireland\\_in\\_a\\_Warmer\\_World.pdf](https://maths.ucd.ie/~plynch/Publications/Ireland_in_a_Warmer_World.pdf)

<sup>11</sup> <http://edepositireland.ie/handle/2262/71304> accessed 08.04.2019



The table below highlights some of the probability study findings from work carried out by ICARUS Climate Research Centre Maynooth.

| Probability  |  |
|--|--|
| <b>Irish extremes – how has their likelihood changed?<sup>12</sup></b> | <p>In a business as usual world:</p> <ul style="list-style-type: none"><li>• 1 in 8 years as dry as 1995</li><li>• 1 in 8 years as wet as 1994</li><li>• 1 in 7 years <b>as cool as</b> 1995</li></ul>   |
| <b>Summer 2018</b>   | <p>In Ireland, there are clear trends towards more heat waves in the observations. An attribution study of summer 2018 extreme temperatures using climate models gives a very similar increase in probabilities to the observations<sup>13</sup></p> |
| <b>Intensity of cyclones</b>   | <p>In the context of a <b>143-year record</b> the winter of 2013/14 was without parallel in terms of the number and intensity of the cyclones endured<sup>14</sup></p>   |



<sup>12</sup> <https://www.sciencedirect.com/science/article/pii/S221209631600005X>

<sup>13</sup> <https://www.worldweatherattribution.org/attribution-of-the-2018-heat-in-northern-europe/>

<sup>14</sup> Matthews, T., Murphy, C., Wilby, R.L. and Harrigan, S., 2014. *Stormiest winter on record for Ireland and UK*. *Nature Climate Change*, 4(9), pp.738-740.

## 4. Priority Impacts and Consequences

Having completed an impact and vulnerability assessment (see background documents) a prioritisation exercise was undertaken. This exercise involved a review of the findings in the vulnerability assessment by the adaptation group. A priority Impact chain was developed setting out those impacts likely to have the greatest effect on the sector. The climate variables identified in section 3.2 relating to air temperature (soil temperature changes are consistent with air temperature), changed precipitation patterns and extreme events were identified as likely to impact on agriculture and forests in the future. The priority impacts and consequences are identified in the table below.

A separate impact and vulnerability assessment and prioritisation exercise (see background documents) identified changes in ocean temperature, changed precipitation patterns and hydrology, sea level and extreme events as the main climate variables likely to impact on the seafood sector.

Section 4.1 illustrates the combined results of these prioritisation exercises.

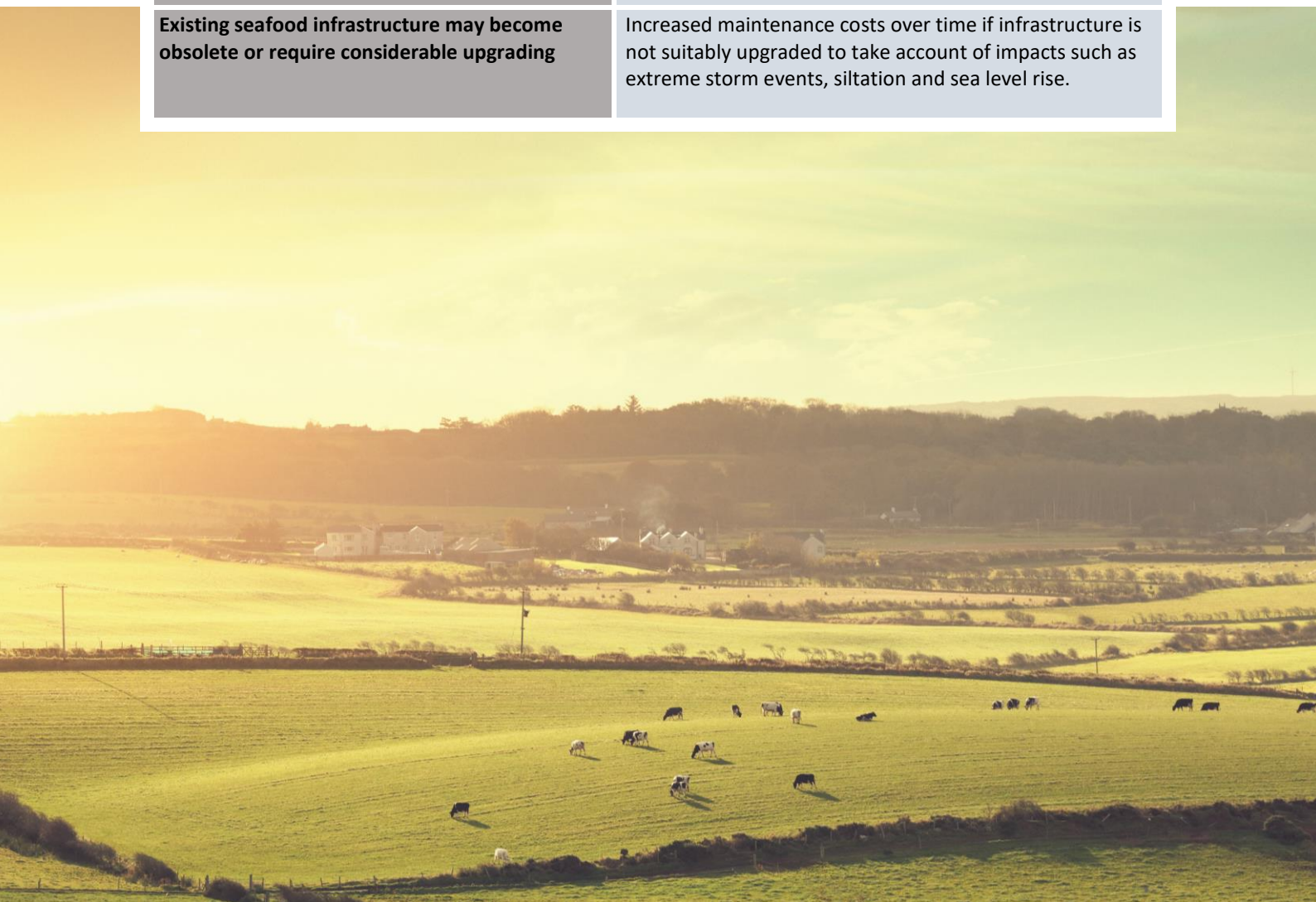
### 4.1 Priority impacts and consequences:

| Impact   | Consequence  |
|--|--|
| Slurry storage and land spreading issues                             | Run-off leading to potential water quality issues.<br>Increased ammonia emissions.   |
| Soil quality/condition impacted by both wet and dry conditions       | Compaction.<br>Trafficability issues for machinery/harvesting.<br>Land poaching caused by livestock.<br>Reduced plant growth leading to lower yields and crop failures.<br>Potential unplanned reseeding/resowing requirements.<br>Soil erosion.<br>Change in the dynamics of land-water exchanges, often leading to deterioration in water quality, increase in Dissolved Organic Carbon (DOC) loadings especially in areas of peat soils – impact on downstream, estuarine and inshore water quality.<br><br>Secondary pressures:<br>Plant health affected causing susceptibility to disease.<br>Poor grass growth leading to increased meal/silage requirements during summer leading to potential winter feed gap. |
| Windthrow- due to stormy weather, greater risk on water logged soils | Damage to forest stands.<br>Mechanical damage to crops.<br>Reductions in forest rotations and timber quality.  |
| Infrastructure damage  | Buildings/protective infrastructure damaged in high winds/stormy conditions.<br>Health and safety impacts on farmers and animals.  |

|   |   |
|---|---|
|   |   |
| <b>Survivability of vector borne disease and possible prevalence and establishment of pest and disease</b>  | <p>Potential for risk of outbreak such as Bluetongue in ruminants.</p> <p>Changes to parasite pressures.</p> <p>Potential affect on pathogens when there is an increase in temperature and by changes in precipitation and moisture.</p> <p>Reduced plant growth leading to lower yields and crop failures.</p>                 |
| <b>Reduced resilience and vitality of forests due to the impact of climate change</b>   | <p>Increasing maladaptation leading to habitat and biodiversity losses, reduced forest productivity, vitality and capacity to sequester carbon.</p> <p>Greater susceptibility to attack by harmful forest pests and disease.</p>  |
| <b>Changing pest and disease behaviour</b>  | <p>Greater activity and impact of endemic pests and disease due to more favourable climatic conditions (coupled with climate change reduced resilience – see above).</p> <p>The establishment of exotic pests and disease due to enhanced and favourable climate change induced conditions.</p>                                 |
| <b>Food safety issues could potentially arise where irrigation interventions are required</b>   | <p>Potential for risk of microbiological contamination of plants and in particular leafy greens.</p> <p>Dry cracked soil could potentially lead to exposure of ground water to pesticides.</p>  |
| <b>Risk of uncontrolled fire</b>  | <p>Risk of serious damage to forest stands, farmland, raised bogs and peatlands.</p> <p>Danger to animals and humans.</p> <p>Air quality issues.</p>  |
| <b>Heat stress</b>  | <p>Heat stress leading to health impacts for animals and farmers.</p>   |
| <b>Reduced shell growth as a result of ocean acidification in commercially important species such as Oysters and Mussels.</b>                                 | <p>Economic losses.</p> <p>Unknown consequences for top predators such as fish, birds and mammals.</p> <p>Decreased seafood production.</p>   |
| <b>Risk to fishing fleets, as well as harbour and aquaculture infrastructure due to increased intensity of storms and the frequency of storm surge events</b> | <p>Damage to vessels and infrastructure including gear loss in inshore and coastal sector of fisheries and aquaculture, such as crab/lobster pots, oyster trestles etc.</p> <p>Fishing fleet would need to tie-up for lengthy periods leading to reduced annual effective fishing effort.</p> <p>Health and safety impacts.</p> |
| <b>Changes to traditional fisheries as the distribution of certain fish stocks moves Northwards.</b>  | <p>Changes in the patterns of time at sea for the fishing fleet.</p> <p>Likelihood of increased fuel consumption.</p> <p>Securing markets for the new fisheries which emerge.</p>   |
| <b>Increased threat of non-native invasive species</b>  | <p>Loss of native species.</p> <p>Loss of biodiversity.</p>   |



|  |   |
|--|---|
| <p><b>Changes in the timing of fish spawning and subsequent changes in the timing of harvesting.</b></p> | <p>Economic losses.<br/>Knock on effects on the survival and development of juvenile fish populations.<br/>Suitable larval food availability reduced as plankton populations move north.</p>  |
| <p><b>An increase in the occurrence of harmful algal blooms</b></p>                                      | <p>Restrictions on shellfish harvesting opportunities with potential for economic losses.<br/>Additional resourcing to ensure monitoring of seafood safety is not compromised.</p>  |
| <p><b>Issues with aquaculture site suitability, access and general site management.</b></p>              | <p>High precipitation results in high river levels and potential flooding of inland aquaculture facilities or damage to intakes.<br/>Low precipitation results in low flows in the rivers, and if combined with high temperatures and the added pressure on water abstraction by public water, then there can be reduced water availability to the inland aquaculture farms. Reduced water availability can lead to increased costs due to the cost of recirculation and oxygenation of the water in the aquaculture farm.<br/>Losses of stock and infrastructure in aquaculture facilities such as clam parks and oyster trestles due to storms, storm surges and freshwater floods.</p> |
| <p><b>Existing seafood infrastructure may become obsolete or require considerable upgrading</b></p>      | <p>Increased maintenance costs over time if infrastructure is not suitably upgraded to take account of impacts such as extreme storm events, siltation and sea level rise.</p>  |



## Sectoral Opportunities

**Greater grass growth** – there is likely to be variation in grass production with seasonal differences in regional grass production – further analysis of future grass production trends is required

Potential for longer grazing season and improved nutrition.  
 Potential for increased autumn and spring herbage production.  
 Potential for better nutrient uptake.

**Changes to plant growth patterns**

Potential for the use of additional plant species and varieties e.g. legumes, horticulture, commercial forest species.

## Climate Change and Business

A 2010 Forfas<sup>15</sup> report identified that while not all businesses will be equally impacted, climate change will impact on Irish businesses through changing markets, impacts on premises and processes and increased vulnerability of supply chains. There may also be implications for investments, insurance costs and stakeholder reputation.

The central conclusion from that report was that properly prepared, adaptation can provide opportunities for businesses in Ireland and that threats can be managed.

**Some examples of Climate change impacts on food and drinks industry include:**

- Extreme weather events can impact transportation and refrigeration of raw materials, such as milk
- Quantity and quality of water available to businesses could be impacted
- Flooding can cause damage to businesses and infrastructure, such as transport or utilities like electricity and water supply.

<sup>15</sup> [http://www.itic.ie/wp-content/uploads/2015/05/Adaptation\\_to\\_Climate\\_Change\\_Summary\\_Report\\_ONLINE\\_FINAL.pdf](http://www.itic.ie/wp-content/uploads/2015/05/Adaptation_to_Climate_Change_Summary_Report_ONLINE_FINAL.pdf)

### **Risk management tools**

Both at primary producer and industry level consideration of appropriate risk-management tools will need to be considered as part of adaptation planning, such as insurance options and early warning systems. Such tools are essential in order to protect against the financial impacts of extreme weather events and changes in climate.

The IBEC publication *Building a low carbon economy - A roadmap for a sustainable Ireland in 2050* includes a recommendation to establish a multi-stakeholder social dialogue on climate action bringing together industry, trade unions, environmental groups, local representative groups and political parties. It goes on to say that achieving a broad national consensus on climate action is vital to ensuring effective delivery and outcomes.

The Report refers to energy resilience but this could be expanded to include a broader focus on building resilience and adaptation to climate impacts. The proposed social dialogue would provide an opportunity to start such a discussion.

Under the current Common Agricultural Policy (CAP) provisions for risk management to address income volatility are set out in the rural development regulation. Risk management tools include for example, financial contributions to insurance premiums covering economic losses to farmers arising from an adverse climatic event or an environmental incident. Currently, such provisions are optional. Farmers have benefited from participation in a range of EU and national schemes and supports which are a key support in rural Ireland. The Single Farm Payment increases income and reduces income variability which is positive in relation to risk management. The Knowledge Transfer Programme also helps in addressing risk management by increasing the knowledge base in the sector including in relation to environmental, biodiversity and climate change issues.

As negotiations on CAP Post 2020 progress, risk management tools may become mandatory. The European Commission identifies direct payments as an important risk management tool currently used to shore up the resilience of 7 million farms, covering 90% of farmed land. These payments represent an average of 46% of the EU farming community but the proportion is far higher in many regions and sectors. Direct payments therefore help ensure that agricultural activity and the EU's vital high-quality food production base continue to be spread around the Union<sup>16</sup>.

Ireland's European Maritime and Fisheries Fund (EMFF) Programme 2014-20 provides for financial assistance towards fishermen experiencing significant economic losses arising from severe storms and other adverse climatic events. The EMFF Regulation requires that this aid take the form of a contribution to payments to fishermen made by a 'Mutual Fund for Adverse Climatic Events and Environmental Incidents' established by fishermen and be funded through the subscriptions of affiliated fishermen. To date, no fund has been proposed by fishermen or their representatives. The Department of Agriculture Food and Marine and Bord Iascaigh Mhara stand ready to provide advisory assistance to fishermen who wish to develop such a scheme. The EMFF Regulation provides for somewhat similar aid in respect of aquaculture, but rather through aid towards the costs of commercial aquaculture stock insurance that covers stock losses arising from adverse climatic

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<sup>16</sup> [https://ec.europa.eu/agriculture/sites/agriculture/files/future-of-cap/future\\_of\\_food\\_and\\_farming\\_communication\\_en.pdf](https://ec.europa.eu/agriculture/sites/agriculture/files/future-of-cap/future_of_food_and_farming_communication_en.pdf)



events. Ireland did not select this measure for inclusion in its EMFF Programme due to prioritisation of funds for capital investment and innovation in aquaculture.

While Ireland’s present EMFF Programme is anticipated to come to a close in 2021, EU legislation for a successor to the EMFF Regulation is at an advanced stage of negotiation among the EU co-legislators. The proposed structure of the next regulation is quite different to the EMFF in that it does not provide for specific measures, but rather allows Members States to implement measures of their choosing that will help achieve the specified objectives of the Regulation. The broad nature of these objectives is likely to facilitate possible schemes for assisting seafood enterprises suffering significant economic losses as a result of adverse climatic events, subject to decisions on investment priorities for the 2021-27 period.

### What we are doing

Climate change adaptation is integrated into a range of DAFM policies, measures and schemes covering the conservation of certain species, the utilisation of efficient breeds by maximising genetic resources, prevention of the potential introduction of pests and diseases, monitoring and controlling pests and diseases, and supporting decision making and risk management in industry. While this work is dynamic and evolving current examples are presented in the table below.

| <b>Current Measures to Address Vulnerabilities</b>  |
|---|
| Inspection of controlled commodities at points of import to prevent the potential introduction of harmful pests and disease.  |
| Departmentally, collaborative initiatives, such as the newly formed ‘One Health’ Scientific Support Team will provide a range of scientific supports on a horizontal basis across a range of Divisions.   |
| The UCD Centre for Veterinary Epidemiology and Risk Analysis (CVERA) supported by DAFM provides epidemiological support for the control and eradication of regulatory and non-regulatory animal diseases and a broad range of other animal health and welfare issues. |
| Early warning systems e.g. blight warning.  |
| PastureBase Ireland, grassland management decision support tool.  |
| DAFM provides surveillance for certain diseases affecting animals and plants which must be notified to the Department if suspected or confirmed.  |
| DAFM funded conservation schemes including Seed Stand and Seed Orchard Scheme and the National Woodland Conservation Scheme.  |
| DAFM updates and maintains a national register of forest basic material, commonly known as the seed stand register, which provides a comprehensive database of seed sources for our future forests.   |
| DAFM is an active member in the European Forest Genetic Resources Programme (EUFORGEN) and has contributed to the pan European EUFGIS network of dynamic forest gene conservation units.  |

The DAFM funded FORGEN programme researches the long-term option for improved forest productivity and timber quality in Ireland.

DAFM issues fire risk warnings and has provided training in the use of prescribed burning.

A number of DAFM funded support tools are available to foresters to support management decisions including Windthrow and the CLIMADAPT tool developed specifically for Irish forests that provides guidance on suitability for climate scenario projections.

Agroforestry has been added to the afforestation scheme. This can provide benefits to crops and animals through the micro-climate created by trees as well as generating additional income to farmers.

The IFORIS (Integrated Forest Information System) computer system was developed to support the in house processing of forestry applications. A number of climate related datasets, including flood risk, have been included in the system allowing industry and DAFM to identify risks at the planning stage.

Knowledge Transfer groups have been established in the Beef, Sheep, Dairy, Poultry, Tillage, Equine and Forestry sectors.

Teagasc ConnectEd Professional Knowledge Network aims to meet the need for greater engagement with professionals and businesses that provide services to the agri-food sector through education, skills development and knowledge exchange.

Short term measures can transform into longer term actions such as the recent establishment of the River Shannon Co-Ordination Group and the Flood Forecasting Unit staffed by OPW and Met Éireann.

The Bord Iascaigh Mhara (BIM) Green Seafood Business Programme provides resource efficiency management support in relation to water costs, energy costs and transport (CO<sub>2</sub> emissions) to Irish seafood companies. A Resource Efficiency Guide for Seafood Processors is available on the BIM website.

The Marine Institute manages the Marine Data Buoy Network in collaboration with Met Éireann. The Network provides crucial data for weather forecasting, risk management for shipping, the fishing community and coastal towns and villages with advanced warnings as well as oceanography research and data on Ireland's deep waters.

Within horticulture DAFM actively promotes and supports practices around adaptation and mitigation through two vital funding supports, the EU Producer Organisation Scheme and Commercial Horticulture Grant aid Scheme.

During the summer months DAFM monitors temperatures in Europe and does not allow ruminants and pigs to travel to or through areas where the temperature equals or exceeds 30<sup>0</sup> C. When animals are being transported by sea, DAFM does not allow transport of animals where there is a wave height of 5m or greater expected on the voyage.



## 5. Cross Sectoral Issues

As identified in the 2017 non-statutory adaptation planning document the agri-food<sup>17</sup> sector interacts with a number of sectors giving rise to both opportunities and risks. There is potential for co-benefits and trade-offs from actions identified in the various sectoral adaptation plans. In particular, as the agriculture and forest sector covers the majority of the land area in Ireland it has the potential to play a central role in the potential development of green infrastructure initiatives and protecting biodiversity to support resilience in other sectors. For example, well managed riparian forests can act as a buffer between water courses and agriculture. Maintenance of sustainable grazing in uplands and in peatlands also has an important role to play in the management of biodiversity, in protecting against fires and can have benefits for flood management<sup>18</sup>. Grazing with appropriate stock types and at sustainable densities can maintain habitat variety, quality and composition and in turn inhibit a dominance of unwanted species. The expansion of scrub species at the expense of other habitats may be contrary to the ecological requirements of the area in question. Well managed vegetation reduces the risk of fires in dry conditions.

Coherence and coordination of the various sectoral plans will be challenging as sectors grapple with issues around ownership and implementation of cross sectoral actions. As set out in the NAF, Departments preparing plans under the Framework are required to consult with other sectors through the National Adaptation Steering Committee to ensure cooperation on cross cutting issues. In addition a number of cross sectoral stakeholder events have taken place. The Department has actively engaged in these processes and has engaged in bi-lateral communications with a view to ensuring greater awareness and cohesion of cross sectoral issues. Sectors where there are more obvious cross sectoral interactions include, but are in no way limited to water, biodiversity and flooding. Potential areas of cooperation include flood forecasting; identification of map boundaries for drainage schemes; maintaining water quality in estuaries; water quality plan and how it naturally overlaps with coastal areas.

This first round of statutory plans will give an overview of the cross sectoral issues arising and will no doubt highlight the need for further engagement if we are to have real coherence and coordination across the sectors. Recognising that there is already a significant level of cross sectoral engagement these mechanisms can be availed of for discussing adaptation issues.

The table below gives an indication of potential interactions based on the thematic areas outlined in the NAF.

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<sup>17</sup><https://www.agriculture.gov.ie/media/migration/ruralenvironment/climatechange/ApprovedAdaptationPlanning040817.pdf>

<sup>18</sup> <https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2019-05/7%20Grazing%20and%20trampling%20final%20-%205th%20November%202014.pdf>



| Theme                               | Sectoral Plan   | Responsible Body   | Relevance to Agriculture, Forest and Seafood Sector  |
|-------------------------------------|---|--|--|
| <b>Natural and Cultural Capital</b> | Agriculture<br>Forest<br>Seafood                        | Department of Agriculture, Food and the Marine               | <p>Agricultural run-off can cause excessive nutrient enrichment which can result in eutrophication which can severely affect the reproduction, growth and survival of fish and other aquatic organisms</p> <p>While forests can have a positive impact on water quality, poorly managed commercial forest operations, including inappropriate planting and harvesting can have negative impacts</p>  |
|                                     | Biodiversity  | Department of Culture, Heritage, and the Gaeltacht           | <p>Land use practices and biodiversity are interlinked for example, maintenance of sustainable grazing in uplands and in peatlands has an important role to play in the management of biodiversity, in protecting against fires and can have benefits for flood management.</p> <p>Agri-food production needs to be compatible with biodiversity goals</p> <p>Biodiversity can help with pest control in agriculture, seafood and forest systems</p> <p>Seafood availability and quality is reliant on biodiversity</p> <p>Seafood production needs to be compatible with heritage goals</p> |
|                                     | Built and Archaeological Heritage                       |  | <p>Interaction between heritage, agriculture, forestry and seafood and the implementation of measures to preserve historic monuments or features on the foreshore, agricultural and forest land or holdings e.g. there are over 1300 Recorded Monuments on the Coillte forest estate alone</p>   |
| <b>Critical Infrastructure</b>      | Transport Infrastructure                                | Department of Transport, Tourism and Sport                   | <p>Adaptation measures for sea-faring vessels, particularly fuel efficiencies, emission reduction measures, etc.</p> <p>Agri-food sector relies heavily on transport networks</p>  |
|                                     | Electricity and Gas Networks<br>Communications Networks | Department of Communications, Climate Action and Environment | <p>Energy security, particularly fuel availability and pricing, is a key concern of the seafood sector</p> <p>The agri-food sector is both a consumer and supplier of energy and will be impacted by, and impact on, actions taken in this sector</p> <p>Resilient communications networks are essential as farmers, fishermen and foresters increasingly depend on information communication technologies</p>   |
|                                     |   |  | Coastal Infrastructure and the fishing and aquaculture industries are particularly vulnerable to impacts of flooding including sedimentation, acidity, salinity and  |

|   |                               |  |  |
|---|-------------------------------|--|--|
| <b>Water Resource and Flood Risk Management</b> | Flood Risk Management         | Office of Public Works                               | <p>contamination of shellfish</p> <p>Fluvial flooding can impact on land management activities and vice versa</p> <p>Potential interaction relating to loss of nutrients to waters from agriculture</p> <p>OPW flood protection to urban areas or installations help reduce the likelihood of pollutants being washed into river systems and down to the sea during high flow/flood events, and the CFRAM flood maps should inform owners/operators of other infrastructure/installations of the potential risk to their assets allowing them to take appropriate protection/preventive measures</p> |
|   | Water Quality                 | Department of Housing, Planning and Local Government | <p>Terrestrial water quality, availability and consumption has a strong influence on coastal and marine water quality and in turn seafood quality and inland aquaculture facilities. Marine finfish sector is 100% dependent on inland freshwater smolt production</p> <p>Water management/conservation adaptation actions could impact on agri production</p>   |
|   | Water Services Infrastructure |  | <p>Well located and managed forests of the appropriate tree species can provide benefits to water catchments, including flood attenuation, bank stabilisation and water quality protection</p> <p>Coastal infrastructure and the fishing and aquaculture industries are particularly vulnerable to impacts of severe weather conditions</p>  |
| <b>Public Health</b>                            | Health                        | Department of Health                                 | <p>Food production is subject to food safety legislation (e.g. hygiene, labelling, etc).</p> <p>Mental Health implications following extreme events</p> <p>Workplace safety, including the impact of a changing climate on workers in the agriculture, forest and seafood sectors</p> <p>Food safety issues for vulnerable persons and associated risk factors in agricultural production of fresh produce, use of water and water treatment technologies in food production.</p>  |

### **Emergency planning**

The Department is the lead agency for emergency planning in relation to animal diseases, animal feedstuffs and food safety. Adaptation planning and emergency planning are integrated from dealing with short term impacts of climate change to building long term resilience. One of the Department's Strategic objectives is to safeguard public health and food safety and authenticity which includes an action to establish, and regularly review contingency plans for emergency response to exotic animal and plant disease/pest out-breaks, feed and food incidents, and deploy such response plans, as appropriate.

Our National Farmed Animal Health Strategy considers climate impact on major disease epizootics. The Strategy adopts a principle of 'Prevention is better than Cure' and recognises that this is of particular significance beyond the farm gate in the context of two major global societal issues – one of which is climate change. In line with our objective to embed adaptation planning in sectoral policies we will also seek its inclusion in emergency plans.

In addition to being lead agency for emergency planning in relation to animal diseases, animal feedstuffs and food safety the Department plays a role in fire management guidance. It has developed a Prescribed Burning Code for Ireland in order to provide guidance to landowners who use controlled burning as a land management tool and has also supported training days and other activities for industry and landowners to support good practice. The Department issues Forest Fire Danger Notices during the main wildfire risk season from February through to September. These notices provide forest owners and managers with advance warning of high fire risk weather conditions, and permit appropriate readiness measures to be taken in advance of fire outbreaks. Forest Fire Danger Notices are generally based on daily Met Éireann Fire Weather Index (FWI) and European Forest Fire Information System (EFFIS) outputs, with additional processing and daily analysis by DAFM, in conjunction with other relevant agencies. Like other forms of weather warnings they are colour coded. Increasing levels of preparation and vigilance are required as the risk levels scale from Green through to Red.

The Department is also an active member of the OPW led "National Flood Forecasting Warning Service Steering Committee" and the "Interdepartmental Flood Policy Co-ordination Group".

This Adaptation Plan will help to inform priority issues for engagement and collaboration.

### **Local Authorities**

Local authorities are key stakeholders for implementation of adaptation actions on the ground. The Department already engages with the LAs across a number of areas including disease control, repair and development of fishery and aquaculture linked marine infrastructures and nitrates inspections.

### **Supply chains**

The Safefood report on the impact of climate change on dairy production highlights the reliance of the sector on imported fertilizers and protein-based feed. Where crop yields are adversely affected by climate change, this will increase farmers' reliance on imported feed. The report goes on to highlight the market-related risk associated with changes in supply and demand from climate change. Such risks can alter both input to and outputs from the producer.

A number of food safety risk channels were identified in the report, including pathogens, chemical contaminants and natural toxins.

Although not assessed in our vulnerability assessment due to the complexity of supply chains the impact of climate change in other countries is predicted to be much greater than in Ireland including further south in Europe which could alter current supply and demand chains leading to opportunities for Ireland. For example some horticultural supply countries are already suffering from a lack of water and this is predicted to become more severe which could open up opportunities for the Irish horticultural sector. The Department actively promotes and supports horticulture practices around adaptation and mitigation through two vital funding supports, the EU Producer Organisation Scheme and Commercial Horticulture Grant aid Scheme. These schemes support the adoption of new technologies such as water saving technologies and sophisticated environmental control systems that help minimise water usage and maximise waste utilisation and increase energy use efficiency and through the Producer Organisation scheme a number of research projects are being funded in this area currently.

### **Stepwise approach to cross-sectoral planning**

Impacts of climate change are not constrained by sectoral or spatial boundaries. Therefore, there is an appreciation for the increasing need for cross-sectoral integration across climate policies. However, at this point in time there is little experience in terms of cross-sectoral adaptation policy. It is anticipated that such policy will be complex and have resource implications that will need addressing. We are still in the early stages of climate policy development and further work is needed to better understand how cross-sectoral integration could be achieved.

A stepwise approach to cross-sectoral adaptation planning would seem logical. This first round of plans is informing baseline information around identification of the sector specific issues and adaptation options. They are also helping to identify cross-sectoral interdependencies, benefits, trade-offs/risks and potential gaps. However, to make progress further targeted research on climate change impacts for the agriculture, forest and seafood sector including examination of cross-sectoral interdependencies will be required to achieve the type of policy integration required for the development of cross-sectoral adaptation plans.



## 6. Adaptation Actions

### *Overall Adaptation Goal*

*Build resilience to the effects of climate change and weather related events in the agriculture, forest and seafood sector, reduce any negative impacts where possible, take advantage of any opportunities and to contribute to achievement of DAFM Statement of Strategy Goals.*

As set out at Section 2 of the Plan, four high-level adaptation objectives have been identified. A number of actions have been identified to help achieve these objectives and are set out in the following tables. These actions are further broken down into more detailed sub-actions, timelines and details of the lead authority and stakeholders in Appendix II.

Adaptation actions and coping measures may involve a mixture of grey, green and soft measures. For example, grey adaptation actions typically involve technical or engineering solutions to climate impacts. Green actions seek to utilise ecological properties to enhance the resilience of human and natural systems to climate change and impacts. Soft adaptation actions involve the alteration of behaviour, regulations or systems of management.



## Adaptation Objective 1

Ensure a joined up approach to adaptation planning in the Department of Agriculture, Food and the Marine

| Action Number | Actions  |
|---------------|--|
| 1             | Mainstream climate change adaptation planning across the Department through development and implementation of a composite adaptation plan for the agriculture, forest and seafood sector     |
| 2             | Work collaboratively with agencies and other departments to develop national policy supporting climate change adaptation and maximising synergies with mitigation                            |
| 3             | Engage with the Common Agricultural Policy (CAP) review to ensure environmental objectives related to climate change mitigation and adaptation are adequately covered in the post 2020 CAP   |
| 4             | Engage with the implementation process of the national policy statement on the bioeconomy to ensure climate change mitigation and adaptation are mainstreamed into bioeconomy implementation |

## Adaptation Objective 2

Raise awareness of the impacts of climate change in the agriculture, forest and seafood sector

| Action Number | Actions  |
|---------------|--|
| 5             | Identify current and potential vulnerabilities in the sector to climate variability and extreme events                                   |
| 6             | Greater integration of adaptation issues into agricultural syllabuses at colleges, third level institutes and CPD courses                |
| 7             | Up skill farmers, foresters and fishermen to ensure they have the knowledge and tools required to implement climate adaptation practices |
| 8             | Continue support for focused climate related research in the agriculture, forest and seafood sector                                      |

## Adaptation Objective 3

Reduce vulnerability of the agriculture, forest and seafood sector to main climate impacts and seek to increase resilience

| Action Number | Actions  |
|---------------|--|
| 9             | Engage with industry to support the sector in building resilience in their systems and practices   |
| 10            | Raise awareness among external stakeholders on climate change and adaptation issues  |
| 11            | Support the sector and foster sustainable growth, development, innovation and adaptation including through LIFE, HorizonEurope, the European Maritime and Fisheries Fund and CAP funding |
| 12            | Raise awareness of health and safety issues arising for those working in the sector particularly at primary producer level   |
| 13            | Greater awareness of OPW flood risk mapping to inform decision making  |

## Adaptation Objective 4

Embed adaptation planning in agriculture, forest and seafood sectoral policies

| Action Number | Actions   |
|---------------|---|
| 14            | Build internal capacity by engaging in knowledge sharing and information exchange to increase awareness of climate and adaptation issues across the Department and its agencies |
| 15            | Promote adaptation screening as part of Department policy development   |
| 16            | Review and update sectoral Adaptation Plan at least every five years  |



## 7. Implementation and Monitoring

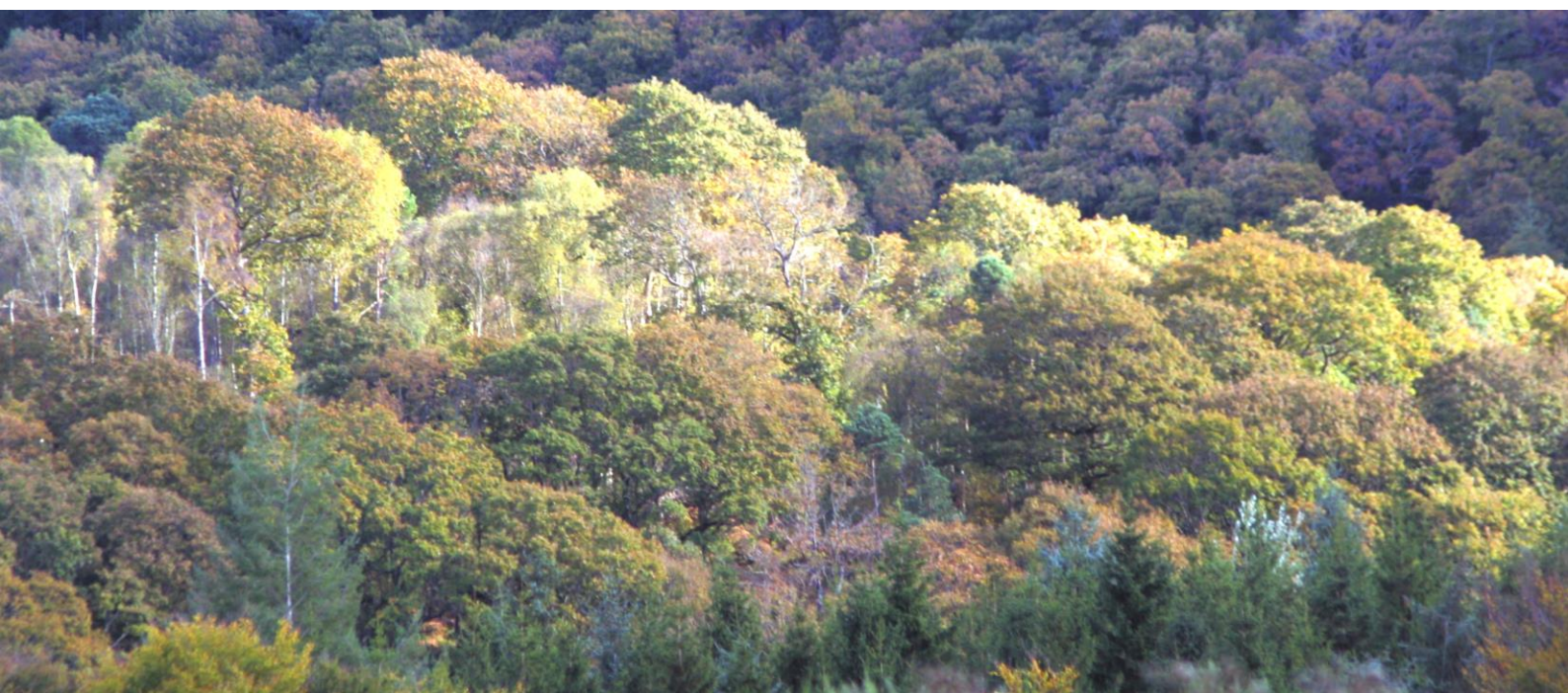
The Department will adopt an iterative approach to monitoring, reporting and evaluating the actions identified in the Plan. An implementation Plan is outlined in **Appendix II**. An annual progress report will be prepared and submitted to the Management Board.

Ongoing monitoring will inform requirements for additional adaptation measures under subsequent plans. The monitoring system will also help to support communication and learning and to indicate progress towards achieving our adaptation goal.

Looking forward, the following indicators may help to demonstrate progress towards an ultimate goal of building resilience into the Agriculture, Forest and Seafood sector against the impacts of climate change:

- Baseline monitoring
- Recognition of adaptation needs within sectoral work programmes (mainstreaming)
- Level of adaptation research
- Launch of adaptation measures/level of spending
- Cooperation with other sectors/sub national levels is planned/happening
- Periodic reviews/evaluations

In the long term however, there will be recurring National Adaptation Frameworks and sectoral plans as provided for by the Climate Action and Low Carbon Development Act, 2015.





## APPENDIX I – Case Studies

### Climate Adaptation - Some Food for Thought Using Case Studies

#### Introduction

Although significant uncertainties exist regarding the extent and impact of climate change in Ireland on the agriculture, forest and seafood sector it is vital that this sector seeks to reduce its exposure to projected changes. As previously identified this can be achieved in a number of ways including through greater understanding of the risks, good animal and plant husbandry and selection, and reducing exposure to pests, diseases and disturbances. Given its inherent reliance on the environment this sector must work with natural processes and within the constraints placed on it by climatic and soil conditions. Nonetheless resilience can be enhanced through appropriate planning and management.

Effective communication, support and collaboration amongst sectoral stakeholders will be central to successful adaptation. The following case studies are a sample of initiatives from across the agriculture, forest and seafood sector that highlight some of the challenges that the sector faces and how stakeholders, both public and private, can work together effectively to identify, quantify and manage climate change related risks and impacts.

The primary aim of these case studies is to provide some food for thought on projected climate change that increases our understanding of the issues involved and thereby promotes a discussion on climate adaptation. It is recognised that climate change adaptation is a hugely complicated issue involving the interaction of a huge number of variables and biological processes and therefore, we need to be careful not to attribute single events to climate change. A longer time period for a full scientific analysis is required, however, the case studies set out in this document are useful in terms of illustrating what climate change might mean for the agriculture, forest and seafood sector.





# Index of Case Studies

- **Case Study 1:** Animal Health and Welfare
- **Case Study 2:** Biodiversity and Agriculture
- **Case Study 3:** Fish Stock Distributions
- **Case Study 4:** Food Safety and Climate Change
- **Case Study 5:** Grassland
- **Case Study 6:** Harmful Algal Blooms
- **Case Study 7:** Horticulture
- **Case Study 8:** Land and Fire Management, Climate Change
- **Case Study 9:** Linking Art and Science
- **Case Study 10:** Ocean Acidification
- **Case Study 11:** Ocean Plankton
- **Case Study 12:** Seafood Infrastructure
- **Case Study 13:** Tillage
- **Case Study 14:** Water in Agriculture
- **Case Study 15:** Windthrow and Forests



# Case Study 1: Animal Health and Welfare

Bluetongue virus (BTV) is a vector-borne disease transmitted to ruminant animals by the *Culicoides* midge species. Vector activity, development rates and susceptibility to infections are all influenced by changing temperatures. Bluetongue emerged dramatically in southern Europe after 1998 and in northern Europe from 2006 and while the speed and scale of this emergence is a challenge to explain, there is evidence, principally from the development of climate-driven models, that recent climate change has played a significant role<sup>19</sup>.

## Impact of Future Climate Change Projections

Temperature increases of between 0.9°C to 1.3°C in summer for the medium to low emission scenario and between 1.1°C and 1.7°C for the high emission scenario are projected in the *Ensemble of regional climate model projections for Ireland* for the period 2041-2060. Winter temperatures show increases ranging from 1°C to 1.3°C for the medium to low emission scenario and an increase of between 1.2°C to 1.7°C for the high emissions scenario during the same period.

High temperatures generally increase the metabolic rates of arthropod vectors leading to an increase in (i) the rate at which they feed, (ii) the frequency with which they deposit their eggs or larvae, and (iii) maturation rates of immature stages<sup>20</sup>. Increased feeding rates enhance chances of pathogen transmission among vectors and hosts. Temperature also influences infection rates and dissemination patterns of pathogens in the vector. Studies conducted in Florida on West Nile virus showed that the highest rates of infection in *Culex quinquefasciatus* were obtained at high temperatures of 30°C<sup>21</sup>. Similar observations have been made with BTV transmission where the ideal temperature for transmission has been established to be between 27 and 30°C<sup>22</sup>.

The high-risk period for Bluetongue in Ireland is during the vector season which is between April and early December each year. If bluetongue is introduced to Ireland, it could have a major impact on our export markets. Also, the control measures required by the EU legislation would have a significant impact on local herd management<sup>23</sup>.

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<sup>19</sup> Baylis, Caminade, Turner and Jones, 2017

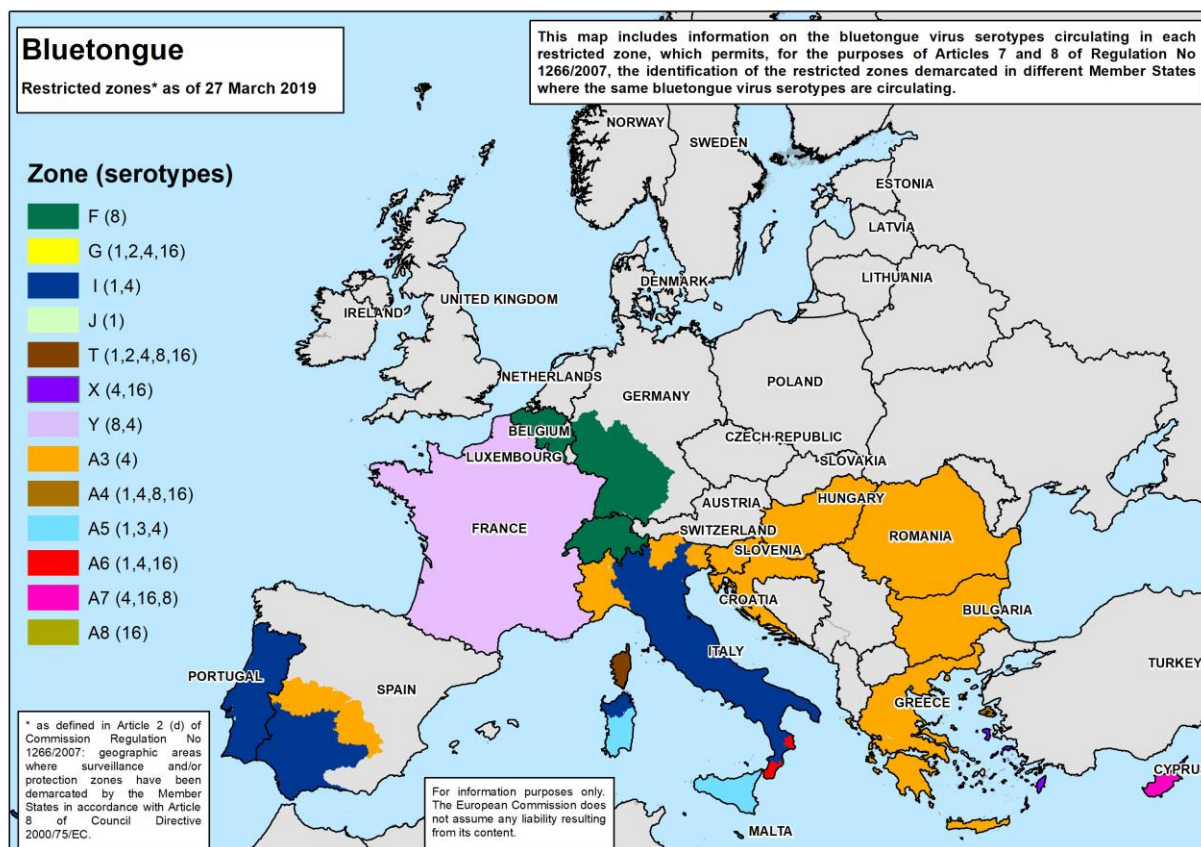
<sup>20</sup> Ahumada et al., 2004

<sup>21</sup> Richards et al., 2007

<sup>22</sup> Mellor et al., 2009

Bett et al 2017

<sup>23</sup> <https://www.agriculture.gov.ie/media/migration/animalhealthwelfare/diseasecontrols/bluetonguedisease/updates/BluetongueUpdate280119.pdf>



Map of Bluetongue restricted zones in Europe as of 27 March 2019<sup>24</sup>

## Steps Towards Building Resilience

Adapting to the changing climate is one of the fundamental challenges facing our agri sector. High standards of animal health and welfare underpin our ability to trade domestically and internationally. There is a significant variability with respect to the impact of climate change on hosts, disease, pests and pathogens.

As the Department seeks to adapt to climate change impact on animal health and welfare, it would seem appropriate for a body of research to be conducted into its impact at a more granular level, prioritising studies that address the main threats – including exotic and endemic diseases, pests and pathogens – and utilising the current climate change projections as the basis for scenario-specific predictive modelling and evidence-based assessments.

[https://ec.europa.eu/food/sites/food/files/animals/docs/ad\\_control-measures\\_bt\\_restrictedzones-map.jpg](https://ec.europa.eu/food/sites/food/files/animals/docs/ad_control-measures_bt_restrictedzones-map.jpg)



## Case Study 2: Biodiversity and Agriculture

From an Irish perspective, biodiversity and ecosystem services have a clear link to supporting our agricultural sector (e.g. clean water, soil and pollination services, etc.). In the Irish study ‘The Economic and Social Benefits of Biodiversity (2008)’, the value of national ecosystem services, in terms of their productive output and human utility, was estimated at over 2.6 billion euros per year. It is now widely recognised that climate change and biodiversity are interconnected. Biodiversity is affected by climate change, with negative consequences for human well-being, but biodiversity, through the ecosystem services it supports, also makes an important contribution to both climate-change mitigation and adaptation.

The European Innovation Partnership (EIP), supported by DAFM called The Biodiversity Regeneration in a Dairying Environment (BRIDE) is an example of an EIP project with climate friendly practices. The objective of the BRIDE project is to design and implement a cost effective, results based approach to conserve, enhance and restore habitats in lowland intensive farmland, and to improve national awareness of the options that are available in an effort to maintain and enhance farm wildlife on intensively managed farmland.



### Impact of Future Climate Change Projections

Climate change is now recognised as a key threat to biodiversity. Climate change has a profound effect on the distribution of numerous plant and animal species. Biodiversity is adapting to climate change either through shifting habitat, changing life cycles, or the development of new physical traits. Butterflies for example, are good biological indicators, they are well documented, easily identified and monitored, and also their life-cycle is affected by temperature. Temperature changes have led to the composition of European butterfly communities shifting northwards during the period 1990-2008 by 114 km<sup>25</sup>. In Ireland, butterfly species that were once confined to the southern half of the country are expanding their range, and the warmer temperatures are attracting new resident butterflies, e.g. The Clouded Yellow.

A changing climate can amplify other key threats to biodiversity such as: pollution of both surface water and groundwater by nutrients or silt; and invasion by alien species of plants and animals.

<sup>25</sup> Regan., E. (2013). Mercury rising: what climate change will mean for Butterflies in Ireland. In: Ireland’s Climate: the road ahead, a Met Eireann publication. p41-46

## Steps Towards Building Resilience

Biodiversity can support efforts to reduce the negative effects of climate change. Conserved or restored habitats can remove carbon dioxide from the atmosphere, thus helping to address climate change by storing carbon. Conservation and management strategies that maintain and restore biodiversity can be expected to reduce some of the negative impacts from climate change.

Options to increase the adaptive capacity of species and ecosystems in the face of accelerating climate change include farm based measures such as those contained in the BRIDE project. As part of BRIDE, farm-based actions will target farmland habitats such as hedgerows, field margins, retention of winter stubble on cereal farms, skylark plots, riparian buffer strips, creation of a permanent pond, conservation of existing farm habitats and native woodlands. An outcome of the BRIDE project will be to produce a Biodiversity Management Plan in consultation with participating farmers that identifies priorities and actions to enhance farmland wildlife which build resilience to climate impacts in the landscape supporting sustainable food production.

The output of the BRIDE EIP will provide a source of measures which have mutual biodiversity and climate benefits and can be adapted for future agri-environmental schemes.



## Case Study 3: Fish Stock Distributions

Temperatures in most seas and oceans around the globe have risen in recent decades. Shifts, usually in a northerly direction in the northern hemisphere, have been widely documented in the distributions of many fish species and are linked to these major changes in environmental conditions. Environmental conditions (mostly sea temperature) determine the distributions of each fish species, but these can be subsequently modified by fishing. As the exploitation of commercial fish species moves towards sustainable levels, the effects of environmental drivers on fish distribution become proportionately more important because of the declining influence of fishing mortality.

### Impact of Future Climate Change Projections

In 2017, scientists from the International Council for the Exploration of the Seas (ICES), examined evidence of distributional shifts in 21 commercially exploited fish species in the North East Atlantic. The species examined were: anchovy, anglerfish, blue whiting, cod, common sole, Greenland halibut, haddock, hake, herring, horse mackerel, mackerel, megrims (2 species), Norway pout, plaice, pollack, saithe, sprat, spurdog, and whiting. The species were examined across the following regions and time-series: Baltic Sea (from 1991), Celtic Seas (from 1993), North Sea (from 1965/1987), and Bay of Biscay/Iberian coast (from 1997). An analysis of bottom-trawl survey information identified species with substantial changes in distribution. This was supplemented with a literature review for all species.

Distributional changes were found for 16 of the 21 fish species analysed. The drivers for these changes in distribution of most of the analysed species are linked to the environmental conditions (i.e. mostly through sea temperature), but for some species fishing also played an important role. Eight species (anchovy, cod, hake, herring, mackerel, plaice, horse mackerel, and common sole) have shifted their distribution in relation to their management areas since 1985. Of these, the greatest shifts occurred for hake and mackerel.

Environmental conditions influenced the distribution of all of the 16 species that showed substantial change; fishing (both overall pressure and effort distribution) influenced the distribution of nine species. Environmental conditions and fishing are interacting factors; both have changed since 1985 and they are likely the drivers of change in fish distributions. The degree to which each has caused change varies between species (and, in some cases, between individual stocks of the species).

For all 16 species that showed substantial changes in distribution, the literature indicates that the main factor influencing the locations of suitable habitats was environmental conditions, mainly through sea temperature. Habitat selection, and the accessibility of suitable habitat, could dictate the actual areas that the species is able to utilize. Similarly, species interactions with predators or competitors might influence the extent to which the species is actually able to utilize particular locations. Conversely, expansion of the species distribution could be inhibited if the species is

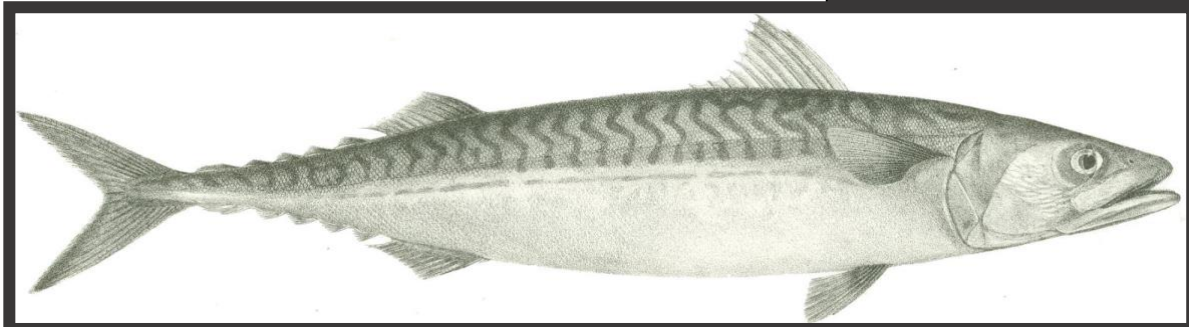
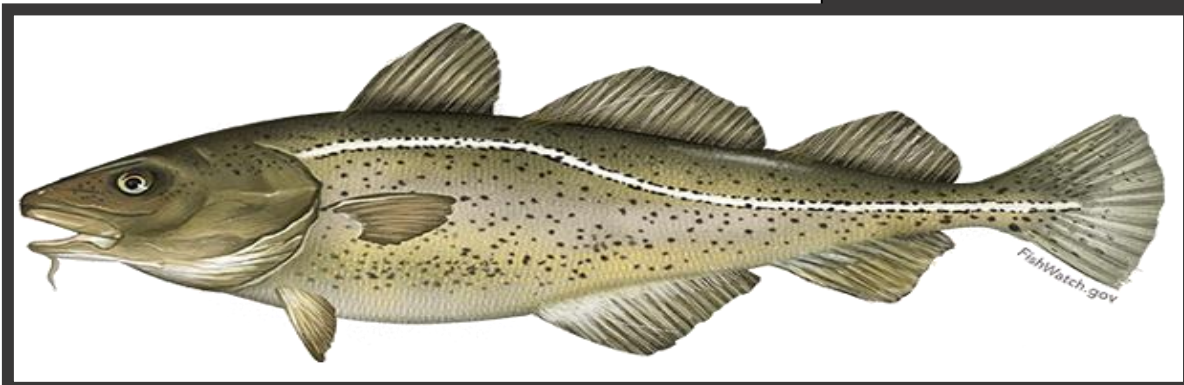
particularly dependent on specific and restricted habitats, or has especially strong geographical attachment to particular sites, such as spawning grounds.

Changing environmental conditions alter habitat suitability at specific geographical locations. The area occupied in times of cooler water temperature may become unsuitable when the temperature rises. Habitat selection could then cause the fish stock distribution to shift northwards, or into deeper water, where a more suitable temperature regime may again be found.

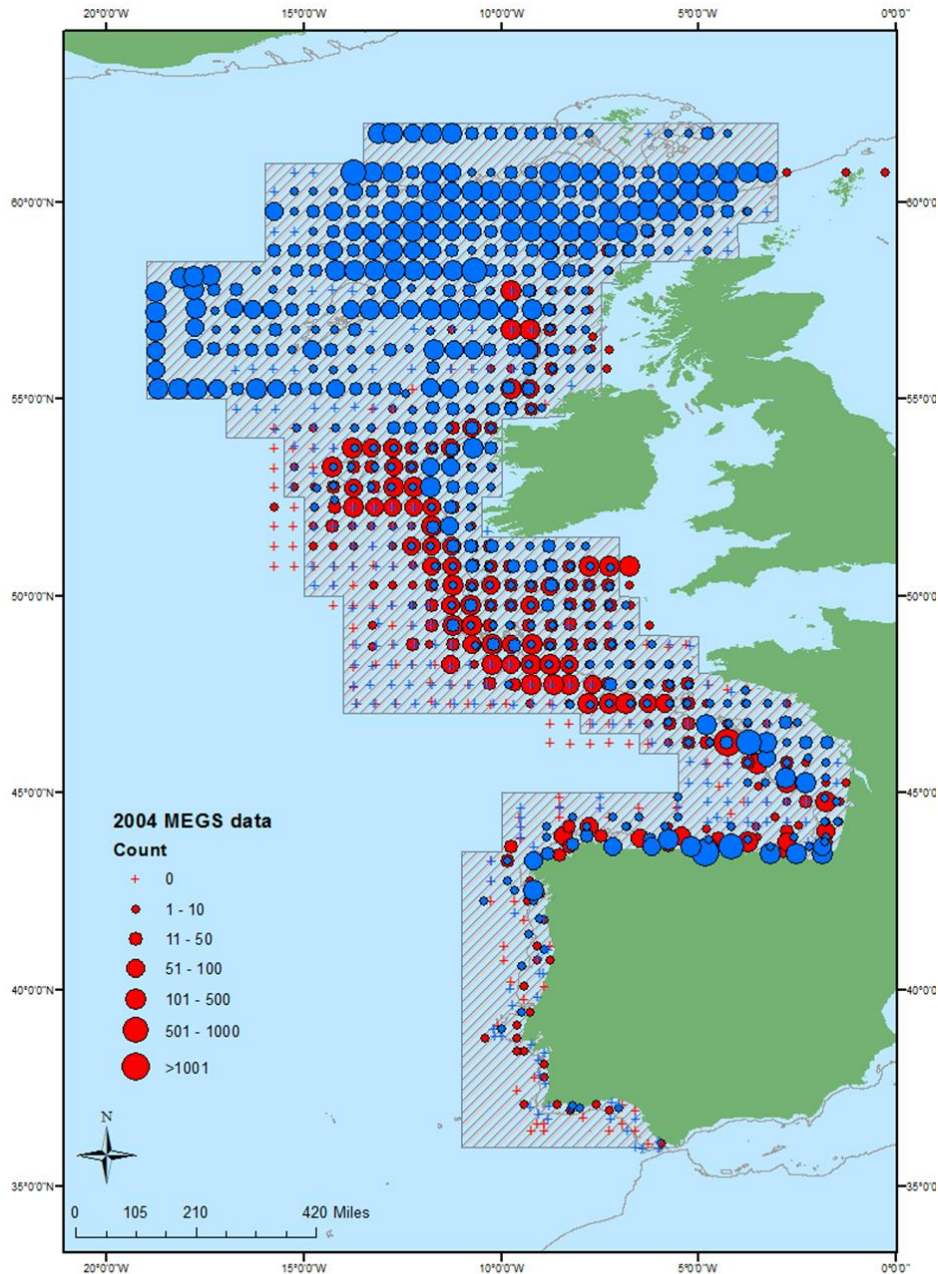
Current climate scenarios project an increase in temperature and changes in primary production; there are therefore likely to be future changes in fish species distribution. The recovery of populations as a result of reduced fishing mortality will also increase the likelihood of distribution change. The ability to accurately predict the future distribution of fish species is hampered by insufficient understanding of the mechanisms associated with drivers, and our ability to predict the drivers.

Future changes in distribution are likely, but given the complexity of the mechanisms affecting the spatial distribution of fish stocks, predicting those changes with precision and accuracy is not possible. It is reasonable to assume that these changes will challenge some assumptions underlying the current management areas for some Northeast Atlantic fisheries. Continued monitoring of the spatial distributions of fish stocks is essential to support future management.

*Scientists have evidence of a northward shift in the cod stocks in the waters around Ireland and a north west expansion in the north Atlantic mackerel stock*







*Mackerel Egg Distributions in the north east Atlantic from the international mackerel egg survey programme. The egg distributions for 2004 are indicated by the red bubbles and for 2016 by the blue bubbles. Note the shift in distribution to the north and the wider distribution pattern to the west of Scotland and Ireland (Data Source from the International Council for the Exploration of the Sea (ICES) 2019).*

## Steps Towards Building Resilience

### Actions required:

- Study the distribution of commercial fish stocks in relation to their management areas.
- Study the current centre of gravity of commercial fish stock spawning areas.
- International science industry collaborative research surveys focused on the timing of the start of spawning of the western component of the NEA mackerel stock have taken place

over the period 2014 to 2018 and must continue.

- Continued monitoring of the spatial distributions of fish stocks is essential to support future management.

**Positive Outcomes:**

- In 2017, the International Council for the exploration of the Sea (ICES) provided scientific advice on the changes in commercial fish stock distributions as a result of climate change.
- Continued monitoring of the spatial distributions of fish stocks is essential to support future management.
- Proposed changes in survey design and timing for the ICES triennial mackerel egg survey 2016 to adapt to climate induced changes. Further science industry collaborations to survey and map changes in mackerel pre-spawning migration, timing and route, will continue in 2019.

**Possible steps towards adaptation through building resilience:**

- Continue to ensure the sustainable exploitation of commercial fish stocks as this will contribute to their adaptation to climate change.
- Focused studies on impact of climate change on fish migration behaviour will contribute to our understanding of climate change adaptation, including the new species entering the ocean waters around Ireland and presenting new commercial fishing opportunities.
- Combined study on the oceanography of the region (western European continental margin) and changes in both spawning distribution and adult spawning migration. These studies should focus on understanding the oceanographic links between migration, spawning behaviour and distribution.
- Study to determine if the extension of the summer distribution of mackerel is more likely to be the result of either climate change mediated effects, or due to the substantially increased stock biomass.
- Continued monitoring of the spatial distributions of commercially exploited fish stocks is essential to support future management.



## Case Study 4: Food Safety and Climate Change

There is still much to be understood about the food safety implications of climate change but there is emerging evidence that food-safety events are linked to adverse weather events. This evidence comes from the observed seasonality of foodborne disease, changes in foodborne disease patterns that occur with temperature changes and the association between adverse weather events and increased incidence of food-borne disease outbreaks.

Verotoxigenic *E. coli* (VTEC) bacteria cause disease in humans. They can be found in the intestines of up to 5% of healthy cattle and can be shed in the manure. The incidence of human infection with VTEC in Ireland is increasing every year, with Ireland having the highest incidence of this disease across Europe. Untreated private water supplies are an important method of spread with VTEC; patients are 3-4 times more likely to have consumed untreated well water than people who do not develop VTEC.

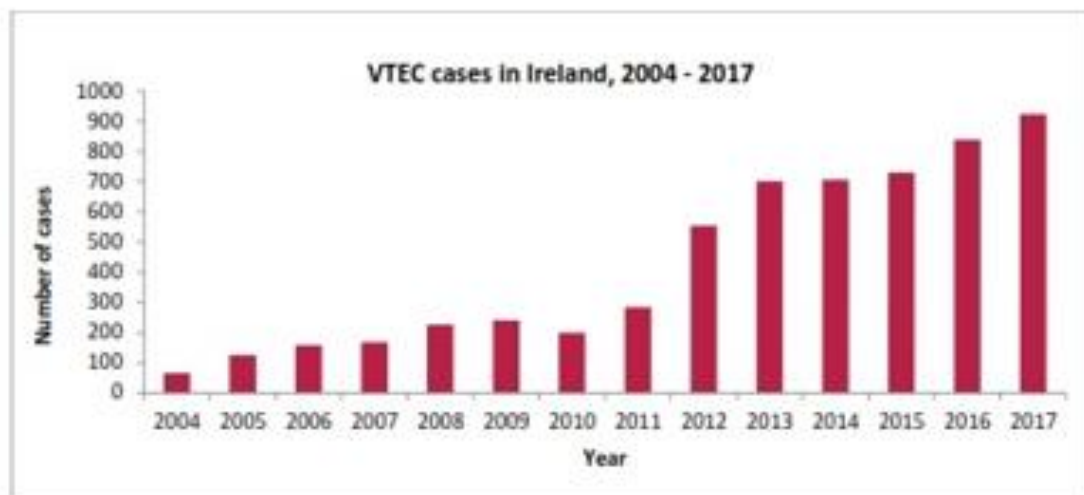


Fig 1: VTEC infection in Ireland – 2004-2017

### Impact of future climate change predictions

Microbiological contamination of the food-chain can occur in a number of ways but contact with human/animal faeces is recognised as an important source. Erratic and extreme changes in climate can impact the dispersion of pathogens in the environment and modify the conditions in which the pathogens survive and/or grow.

Extreme weather conditions (e.g. flooding or drought) can impact the availability and quality of water. Following periods of heavy precipitation, contamination of water-sources from slurry spread on fields and human sewage are commonly reported. This effect is exacerbated following periods of drought when the absorption potential of land is decreased, resulting in greater run-off. A report by

the EPA<sup>26</sup> has predicted a 20% increase in the number of heavy rainfall events with an overall reduction in annual rainfall for the period 2041-2060 – i.e. drier periods followed by flooding – conditions favouring water source and environmental contamination with microbial pathogens.

A less direct potential impact of climate change is the effect on microbial survival, evolution and stress-response. Microbes can survive longer in milder conditions. Exposure to climate-related 'stressors' can alter the bacterial cell, providing it with additional resistance to future stressors. Pathogens that cause disease at very low doses, that can persist in the environment and that exhibit stress tolerance responses are likely to survive and compete more effectively in the face of climate change. VTEC exhibit these properties.

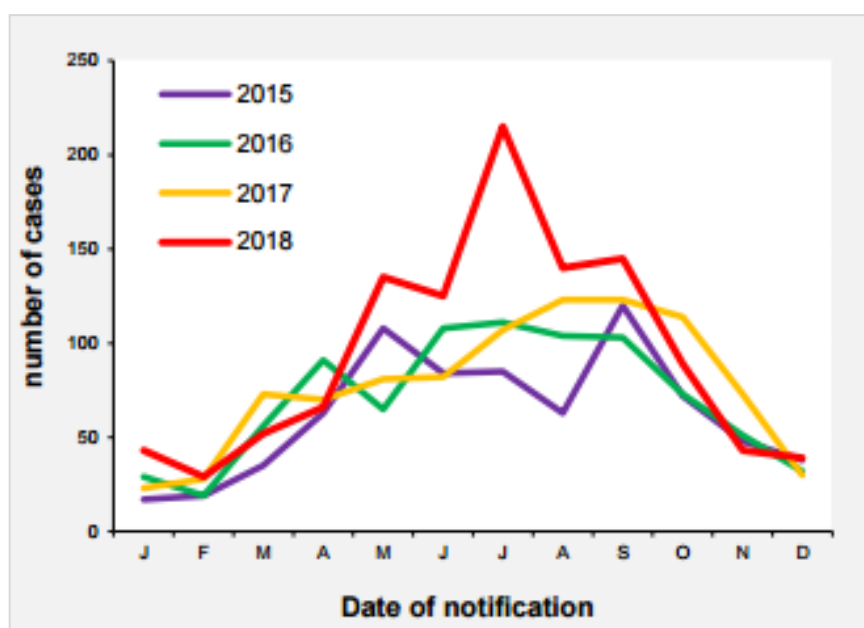


Fig 2: Seasonal distribution of VTEC cases notified 2015 to 2018 in Ireland

VTEC show a seasonal distribution with a significant increase in cases seen in warmer months (Fig 2). Research by Fluery et al (2006) demonstrated a 6% increase in *E. coli* weekly case counts for every degree increase in weekly mean temperature. An outbreak in Ireland in the summer of 2018 was epidemiologically linked to consumption of leafy-greens from 3 farms, 2 of which had previously been associated with cattle.

Environmental transmission from irrigation with contaminated water was suspected although not confirmed by repeated sampling. A low infective dose and the complex matrices of food complicate the detection of VTEC. The behaviour of this pathogen suggests that climate change will favour its dispersion and survival in the environment and could lead to further increases in disease outbreaks in future.

<sup>26</sup>[https://www.epa.ie/pubs/reports/research/climate/EPA%20159\\_Ensemble%20of%20regional%20climate%20model%20projections%20for%20Ireland.pdf](https://www.epa.ie/pubs/reports/research/climate/EPA%20159_Ensemble%20of%20regional%20climate%20model%20projections%20for%20Ireland.pdf)



## Steps towards building resilience

An understanding of the microbiological hazard, predicting its behaviour and spread in the environment, preventing its presence in foods and improving detection are all required to formulate strategic and effective food safety management systems. These are vital in preventing an increased risk from food-borne diseases in the face of climate change.

In order to better understand the risk climate change will pose on food-safety, research is being performed to examine the links between flooding and the incidence of outbreaks of waterborne diseases in Ireland. Mathematical modelling in microbial ecology is evolving and will provide important predictions on the impact of weather events on disease risk from foodborne pathogens.

Detection of pathogens is key to prevent their entry into the food-chain. Research into the development of sensitive and specific methods to detect pathogens in food and water is ongoing. An ideal test would be rapid, inexpensive, portable and provide enumerative results. Huge advances have been made in technology used to identify pathogens with Whole Genome Sequencing providing the ability to identify identical strains and cluster related isolates in outbreaks.

Transcriptomics and proteomics will assist in identifying the physiological state of pathogens and characterising their growth on specific matrices, and their response to different processing treatments. Research into novel processing techniques which are effective in reducing microbial risk without impacting the organoleptic quality of the food is gaining momentum and these techniques may become main stream in future.

Climate change has the potential to impact on food-safety through increased spread and survival of pathogens. Mitigation of these risks through better prevention, detection and elimination should reduce this impact.

## Case Study 5: Grassland

Ireland is a predominately livestock country with 81% of agricultural area devoted to grassland. Grassland and its productivity are central to our livestock systems. The economic importance of the livestock sector at farm level is well established.

Weather is highly important for our livestock systems. It determines the length and success of the growing season and the productivity of livestock. The impact of weather events arising from climate change poses risks to the primary production sector. The cause of these risks includes too much or too little rainfall, particularly at the shoulders of the year, or too high or low temperatures, within a short time period. The impact of these events can have significant implications on fodder production. This has been recently demonstrated through severe weather conditions in 2018.

### Impact of Future Climate Change Projections

In relation to extreme temperatures and heat waves, warming is projected to be enhanced with highest daytime temperatures in the warmest 5% of daily maximum summer temperatures projected to rise by 0.7°C to 2°C for the medium to low emissions scenario and from 1.3°C to 2.6°C for the high emissions scenario. The number of dry periods (at least 5 consecutive days for which the daily precipitation is less than 1mm) is projected to increase substantially by mid century during summer by 12% to 40%.

*Dealing with drought<sup>27</sup>*



In 2018, there were two extreme weather events; firstly, cold weather in March 2018 prevented farmers from grazing livestock due to snow, high rainfall and poor grass supply. The impact of this was farmers needed to have an adequate stock of conserved fodder and sufficient slurry storage in

<sup>27</sup> <https://www.farmersjournal.ie/drought-advice-clinics-for-ailing-farmers-385184>

place to manage and plan for this event. Also in 2018 an extended dry period impacted on grassland growth rates during the main grazing season, resulting in a requirement for significant supplementation to offset poor grass growth. Dairy cattle are particularly susceptible to heat stress caused by high temperatures and humidity. This can affect growth, milk production and fertility. The results of this event lead to the feeding of conserved fodder and concentrate feeds during this period which had implications for fodder stocks for the following winter period. The result of these events has focussed the livestock sector to ensure grassland production systems are sufficiently robust to withstand the risks of climate impacts by ensuring future planning for such events is in place.

The impacts of the events of 2018 mirror those of the events experienced in 2012 and 2013. The growing season in 2012 was poor, followed by a long winter into 2013. This affected both grass and other fodder crop production, leading to a shortage of fodder on many farms and increasing the dependency on external feed. Internationally, there was a poor harvest so feed prices were high. This led to financial difficulties for many farmers.

The resultant impact of the weather events on grassland in 2018 resulted in an overall decrease of 3 tons of dry matter per hectare of grass produced. To mitigate for such events our grassland production must be robust enough to deliver on the requirements of the sector. More planning is required to consider how to deal with extreme weather events at farm level. The monitoring of grass growth and knowing the individual farm grass growth potential is essential to ensure farmers are stocking farms appropriately to the farms ability. The establishment of appropriate fodder reserves is critical to ensure farms are self sufficient.

While the internal factors outlined provide a significant impact on primary production, the potential external impact may have a greater influence on the agricultural sector, for example potential impacts on exports due to reduced milk supply and in turn reduced product supply to the market. Our carbon footprint for our products produced may be affected due to the requirement to import more feed to support and feed the sector.

## Steps Towards Building Resilience

Identifying adaptations that address some of the risks identified will be key. The vulnerability to these risks is dependent on the level of adaptation that takes place within the industry.

### **Adaptations identified from fodder shortages in recent years include:**

1. Farmers need to prepare an annual winter feed budget to establish deficits. It is recommended that a winter feed budget be incorporated into Pasturebase Ireland. This may require that fodder supply agreements or partnerships will need to be generated between livestock (dairy and drystock) and possibly tillage farms for the supply of feed between farms.
2. The requirement for farmers to build a fodder reserve to insulate against poor growth conditions within year. The cumulative effect of weather events in 2018 was a grass growth reduction of almost 3.0 t DM/ha in the worst affected regions. This is an estimated 1 t DM

deficit/cow, which is instructive as to potential scale of reserves required for future events. A practical guideline would be to carry at least 50-80% of this figure (500-800 kg DM/cow) as feed surplus above the normal stocks needed to balance the system. This would be built up over time and vary with degree of risk per farm.

3. The need for an early warning system to identify deficits in feed. This would require a national fodder survey being completed on an annual basis and also making best use of satellite mapping to identify areas of the country worst affected.
4. Soil fertility remains a significant issue in grassland. Anecdotal evidence would suggest that outside blocks of land, particularly on short term lease, have significantly poorer soil fertility than the main block of farmland on many farms. This leads to a poor grass growing capacity, likely overestimation of the animal carrying capacity of the land and consequently inadequate winter feed being conserved.
5. The need for improvements in grazing infrastructure and infrastructure for feed storage and feeding facilities.
6. Continued monitoring for new pests, diseases and weeds is a threat while some existing pests, diseases and weeds may no longer be an issue.
7. Ongoing Value for Cultivation and Use (VCU) trials conducted by DAFM over 3 years to identify robust varieties with the ability to deal with the extremes of climate change.
8. Breeding more heat-resistant varieties of grass and crops and identifying the livestock with genetics better suited to certain environments.
9. Increased diversity of the sward, which if managed suitably and sensitively (including for biodiversity) could strengthen resilience of productive capacity.



## Case Study 6: Harmful Algal Blooms

**Harmful algal blooms (HABs)** in Irish waters already cause significant economic damage to wild fisheries and aquaculture on an annual basis by making shellfish unsafe to eat and causing occasional fish kills. Preparation for significant range expansions of these blooms and increasing biotoxin problems due to changing marine environments will call for increased vigilance and possible adaptation in seafood-biotoxin and HAB monitoring programs.

### Impact of Future Climate Change Projections

A recent review of the response of HABs to oceanic climate change identified the relevant parameters that may impact phytoplankton blooms on a decadal timescale. Key factors include changes in temperature, salinity, surface stratification, alteration of ocean currents, alteration to nutrient upwelling, elevated CO<sub>2</sub> levels (leading to increased photosynthesis), reduced calcification from ocean acidification, and changes in land runoff and micronutrients. The resulting impacts may include:

- i. Expansion of warm-water species at the expense of cold-water species, which are driven pole-ward. This may lead to the introduction of more toxic species into Irish waters that are currently at the northern limit of their distribution.
- ii. Species specific changes in abundance and the seasonal window of growth of HAB species. This could result in a smaller period of time when shellfish are non-toxic, or a longer high risk period for fish kills due to blooms than is currently experienced.
- iii. Earlier timing of peak production of some phytoplankton. This could have knock on impacts for recruitment and growth of fish and shellfish species due to a mismatch or insufficient prey species required for growth.
- iv. Secondary effects for marine food chains, notably when “grazers and their food source” are differentially impacted by climate change (“match becomes mismatch”). The marine food chain is an intricate connection of species that grow and decline in a prey/predator cycle. Disruption to this cycle from climate change may lead to collapse of economically important stocks.



*Harmful  
Phytoplankton -  
Dinophysis species  
which cause  
Diarrhetic Shellfish  
Poisoning*

Since 1998, increases in some phytoplankton groups are evident for all Irish coastal regions with a significant increase in diatom (single cell algae) abundance observed, particularly during the early part of each year. In addition, based on observations from the Continuous Plankton Recorder data which has been in operation since 2000, an expansion of the growth season has been observed and an increase in phytoplankton biomass is evident in the northern Celtic Sea. While the total annual abundance of harmful and toxic species varies greatly between years, the percentage occurrence of some harmful species during the winter months has increased since 2000.

Marine *in-situ* data networks are essential to monitor and detect environmental and climate change (both natural and human induced) and their associated impacts on the fish and shellfish sectors. A designated long term climate network of sentinel sites does not currently exist in Ireland.

### Steps Towards Building Resilience

A long term commitment with financial support is essential to collect scientifically sound long-term datasets to support policy. Support from national government is therefore required to establish a long term climate network of sentinel sites in aquaculture areas to provide for long term baseline monitoring of coastal waters to detect climate-induced change in water biology, chemistry and physical quality, contaminants, phytoplankton, zooplankton, microbiology, macro-algae, benthic invertebrates, fisheries, alien and non-native species.

#### Such a network would support efforts to:

- 1) Map and track the climate change impacts such as the arrival of new and/or invasive species.
- 2) Develop chemical methods to detect trace levels of new shellfish and finfish phytoplankton biotoxins in order to alert agencies to the arrival of new toxins in regions in advance of them causing any consumer or economic hardship.
- 3) Provide key future management tools to improve shellfish harvest schedules including:
  - i) An operational short term HAB forecast system.
  - ii) Biophysical models that mimic the behaviour of target HAB species. This could help determine what, if any, early season and spatial environmental forcing are responsible in the initiation and promotion of blooms and toxicity. Seasonal forecasts are ideally what the industry needs in order to plan production, harvests and markets well in advance. For this, temporal fluctuations of the physical, chemical and biological conditions that control the HABs in the coastal environment need to be explored further.
  - iii) Range extension of toxic phytoplankton leading to novel and emerging toxins in shellfish will require additional resourcing to ensure the monitoring of seafood safety is not compromised.
  - iv) Prediction studies on the response of different HAB groups and genera to the influences of climate change.
  - v) Modelling climatic changes on phytoplankton communities and changes in primary productivity impacts cascading through marine food webs.

**Positive Outcomes:**

- Increases in the phytoplankton abundance of non-harmful species may lead to increased shellfish growths.
- Increases in biomass at the base of the food web may also present an opportunity to rear novel species such as abalone, sea bream/ sea bass, seahorses and urchins.
- HABs associated with cold water conditions may decline.

**Possible steps towards adaptation through building resilience:**

- A climate related network to foster close cooperation and dialogue between industry, state agencies, regulators and cross-border forums and enable a joint effort to combat climate related challenges.
- Provide an enhanced HAB situation awareness by setting up a HAB warning alert system (end to end system that integrates all ocean and ecosystem observing data) to give the aquaculture industry time to prepare for arrival of toxic and nuisance species.
- Switch to more resistant / tolerant fish and shellfish.
- To alleviate stress of fish exposed to high biomass HABs fish farmers could introduce mitigation measures such as the use of aeration of cages, translocation of cages, clay treatments.

## Case Study 7: Horticulture

The Irish horticultural industry makes a very significant contribution to the Irish gross agricultural output with an estimated farm gate value of €437 million in 2018. Within the industry there are a diverse range of sectors, from edible crops such as mushrooms, field vegetables, outdoor fruit and protected fruit and vegetables, to amenity crops such as hardy nursery stock production, bedding plants, turf grass, cut foliage and Christmas trees. For most sub sectors within the horticultural industry, the cost of production and the value of output are significantly influenced by prevailing weather conditions.

### Impact of Future Climate Change Projections

According to the *Ensemble of regional climate model projections for Ireland* report, the projected change for the period 2041-2060 will see an increase in the number of heavy rainfall events by approximately 20% during the autumn and winter months. A projected increase in mean precipitation for winter was noted over most of Ireland for the high-emission scenario. The impact of such severe weather conditions was evident in 2018, with significantly delayed plantings in particular for outdoor vegetable crops and in some cases sowings/plantings being missed altogether because of wet soil conditions.

#### *Nucleus seed potato stocks growing in the field*

Early vegetable crops that would have been sown or planted out in March were skipped; other crops were planted out in less than favourable conditions, a situation made worse with the subsequent drought due to initial poor establishment. The subsequent extreme warm weather had a dramatic effect on production costs where input costs increased substantially. Additional fuel and labour costs were required to irrigate growing crops in an attempt to maintain yield and quality and additional energy was required to chill crops post harvest and to maintain temperatures at acceptable levels within protected structures such as glasshouses and mushroom tunnels.





Harvesting and labour costs increased where the extreme weather resulted in rapid ripening of crops and in cases adversely effecting crop quality where discoloration and bolting became an issue. This resulted in the need for rapid and regular harvesting of crops. Further the warm and dry weather increased pest and disease pressure in crops and reduced the efficacy of available crop protection measures. Production in 2018 was impacted where expected yields were not attained for many crops, in particular for potatoes where yields were back by up 30% on previous year.

### **Steps Towards Building Resilience**

The vulnerability of the sector to increased temperature and drought is evident. Adaptation strategies that address this risk will be critical. Innovation and advances in crop breeding and plant genetics will be important; to include developing stress tolerant varieties that will help cope with increased temperatures and drought, in addition to better pest and disease resistance.

Many of the adaptation actions identified in the Tillage case study (case study number 13) are also relevant to horticulture.

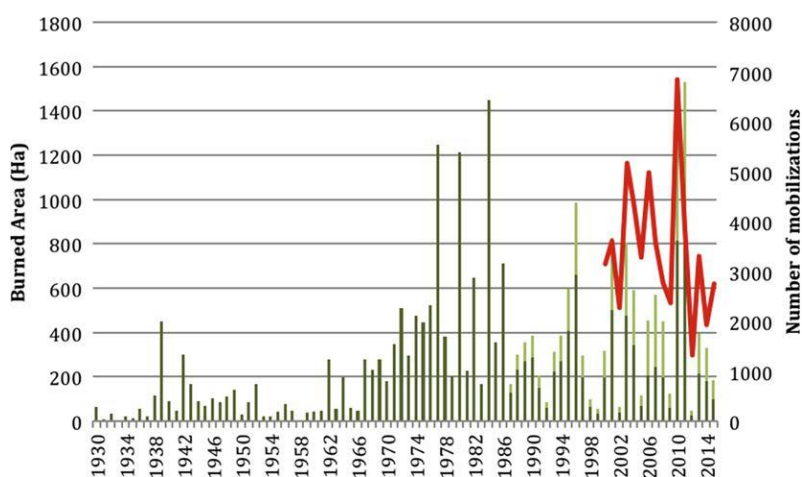


## Case Study 8: Land and Fire Management, Climate Change

Wildfires are an increasingly visible problem in Ireland and across other northern European States previously not familiar with this type of risk. This issue is in part linked with climate change but has also been heavily influenced by changes in land use patterns and rural demographics in recent decades. The conditions for increases in fires and risk are associated with increased temperature, soil moisture deficits and the levels of potential fuel load. These factors can have direct and indirect links to climate variability and climate change.

### Impact of Future Climate Change Projections

Temperature increases of between 0.9°C to 1.3°C in summer for the medium to low emission scenario and between 1.1°C and 1.7°C for the high emission scenario are projected for the period 2041-2060. These types of fires have proven capable of not only impacting severely on forests and habitat areas, but also increasingly threaten rural communities located in fire prone areas. On average 4,000-5000ha of open land is affected by fire annually and up to 500ha of forest land can be affected by fire annually. Emissions from fires are also accountable under the EU LULUCF regulation under the provision of natural disturbances and affect total emissions.



Combined forest area burned and annual Fire Service mobilizations to bog, grass, and forest fires.

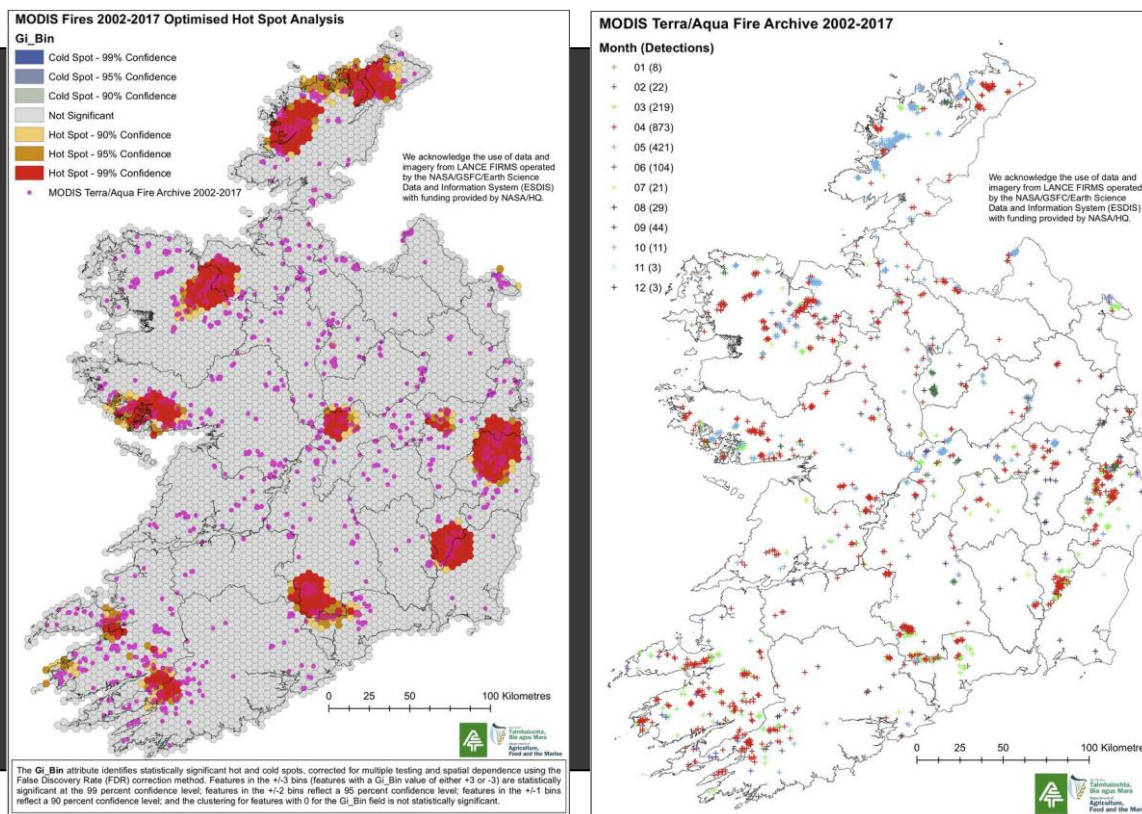
Bars: Area burned, dark green public area, light green private area. Red line: number of Fire Service mobilizations.

Source: Department of Housing, Planning, Community and Local Government and Department of Agriculture, Food and the Marine (DAFM).

During 2010-2011, following catastrophic fire incidents in 2010 the 'Land and Forest Fires Group' met and produced a number of recommendations. These were largely focussed on awareness-raising and research/evidence base requirements of fire management. Development of management approaches was initially constrained by the absence of available data relating to fire occurrence. Access to available satellite based data sources, facilitated through the European Commission, enabled a data resource to be developed to assist further developments. In the period



since 2011, a larger data resource has been developed and this has permitted accurate spatial and temporal analysis of fire risks and occurrences, and the backgrounds to these.



**Optimised Fire hotspot locations and historic fire incidence locations 2002-2017. Source NASA/ESA/DAFM**

Ireland’s initial response to wildfire challenges has been defined by international cooperation and exchange. In the absence of a formal National Wildfire Strategy, DAFM adopted FAO Voluntary Fire Management Guidelines on an ad hoc basis. Additional FAO guidance for North African and Middle Eastern Countries has also been successfully adapted for use in Ireland, to guide initial development. Both of these documents advocate the use of integrated, adaptive management approaches to fire management that are already in use in Southern European Member States and in North America.

FAO Guidance places a heavy emphasis on concurrent developments across all areas of fire



**Wildfire Adaptive Management Cycle**

management – Fire Detection and reporting, Fire Suppression, Fuels management, Post fire recovery and Prescribed Fire. There is a clear understanding that the role of upland farming is central to long term fire management development, both in terms of reduction of problem ignitions and the long term management of hazardous fuels. It is expected that with increasing temperatures resulting from climate change that the conditions favourable for fire will increase into the future. Operational training exchange between fire services and land management experts from Ireland with Spanish, Portuguese and US Fire authorities has accelerated the development and delivery of modern



approaches to fire management, in particular in the area of strategic fuels management and prescribed fire. Irish fire officers undertook specialist Technical Fire management training in Spain, and introduced modern prescribed fire approaches into Ireland.

### **Steps Towards Building Resilience**

Arising from DAFM analysis of fire activity hotspots, a number of European Innovation Partnership projects in these areas have had specific fire management modules built in, towards improving practice on the ground by farmers, and introducing locally led fire management capacity. Local Level fire management partnerships have also been established in Counties Cork, Kerry and Laois, with a view to establishing and improving relationships between relevant local stakeholders and agencies that can positively influence fire management outcomes.

In the light of current climate change projections, recent major wildfire events and impacts in Ireland, and the likelihood of increasing wildfire risks in the decades to come, there is a clear and present need for policy adaptations to meet these challenges.

Agriculture is by far the most important sector where wildfire is concerned, and has the capacity to strongly influence future fire outcomes through adapted land management activities and improved landowner attitudes.



## Case Study 9: Linking Art and Science

Many issues facing society, such as climate change and climate adaptation demand community support, but community support is only likely if the issues are widely understood. Scientists often find it difficult to communicate effectively with the public on complex scientific issues such as climate change. The role of art is often overlooked as a tool to help explain complex scientific issues, yet art has long communicated issues, influenced and educated people and challenged dominant societal paradigms.

### BLUEFISH

BLUEFISH is a marine science research project that focuses on the potential impact of climate change on coastal communities of Ireland and Wales. The project is a partnership between six organisations in Ireland and Wales including the Marine Institute, University College Cork, Bord Iascaigh Mhara, Bangor University, Aberystwyth University and Swansea University.



*Róisín Curé (Ireland) March 2019  
Ink Sketches and Watercolour  
Ecosystem Goods and Services  
The Impacts of Climate Change*

One of the tasks of the BLUEFISH project was to travel around the coastal communities in Ireland and Wales that border the Irish and Celtic Seas. The purpose was to engage with these coastal communities, gathering their opinions on the importance of the ocean to their businesses and to listen to their concerns on climate change and how it might affect their livelihoods. The medium of art was also used to record their daily activities from a broad spectrum of marine activities including



fishing, aquaculture, leisure, transport, tourism, marine renewable energy. The coastal communities of Dingle in County Kerry, Baltimore in County Cork, Kilmore Quay County Wexford and Howth in County Dublin were visited in the summer of 2018. The Welsh coastal communities visited included the Isle of Anglesey, Bangor, Pwllheli, New Quay, Milford Haven and Pembrokeshire.

The resultant watercolour illustrations were created by Galway artist Róisín Curé. They represent a very visual record of the importance of the ocean to these coastal communities. The associated quotes convey the concerns of these communities on climate change and its impacts on their livelihoods.

Róisín explained *“I felt privileged to sketch, at close quarters, people whose ingenuity has turned a potentially hostile ocean into a source of income. I hope that the same ingenuity will provide the answers to the challenges we’re facing with the effects of climate change.”* Some of the quotes captured from the Irish and Welsh coastal communities included the following;

*“Without the ocean, we wouldn’t have a living:  
it’s our only source of income in this rural part of Ireland.”*

*“The sea is vital to our work. Climate change affects  
everyone’s business at the end of the day.”*

*“Everything we do here revolves around the ocean.”*

*“I don’t think about climate change much.  
I don’t think it will change our business in my lifetime.”*

*“Our climate has been out of character, with longer winters that have been bad for  
business. But the nicer summers have been positive for us.”*

*“in the 38 years I’ve been working here,  
the road would have flooded twice a year.  
Now it floods much more often.”*

*“The change in weather has been affecting the mussel seed.  
We have very little this year.”*

*“This summer, it was so hot we ran out of drinking water on the ferry. Normally storms  
start at the end of October, but in September we already had two cancellations  
because of bad weather.”*

There are other art initiatives underway within the BLUEFISH project. The resultant artwork will be used to demystify the complex science behind climate change and to promote climate adaptation.

The BLUEFISH project is funded by *The Ireland Wales 2014-2020 European Territorial Co- operation (ETC) Programme*. The purpose of this maritime programme is to connect organisations, businesses and communities on the West coast of Wales with the South-East coast of Ireland.



## Steps Towards Building Resilience

### Actions required:

- Continue to engage with coastal communities on the value of healthy marine ecosystems to their livelihoods.
- Demystify the concept of ocean “ecosystem goods and services” and “climate change.”
- Continue to engage with coastal communities on the potential impacts on climate change.

### Positive Outcomes:

- Results from these actions should deepen the awareness and understanding of coastal communities on the value of a healthy ocean to their livelihoods and on the potential impacts of climate change.
- Many issues facing society, such as climate change and climate adaptation demand community support, but community support is only likely if the issues are widely understood. BLUEFISH will deepen coastal community understanding of climate change impacts.

### Possible steps towards adaptation through building resilience:

- To address climate change vulnerability, management systems must create opportunities for fishers, fish farmers and fish workers to remain flexible and to be able to sustainably utilise diverse livelihood opportunities.
- Climate change adaptation strategies must include the participation of all stakeholders.

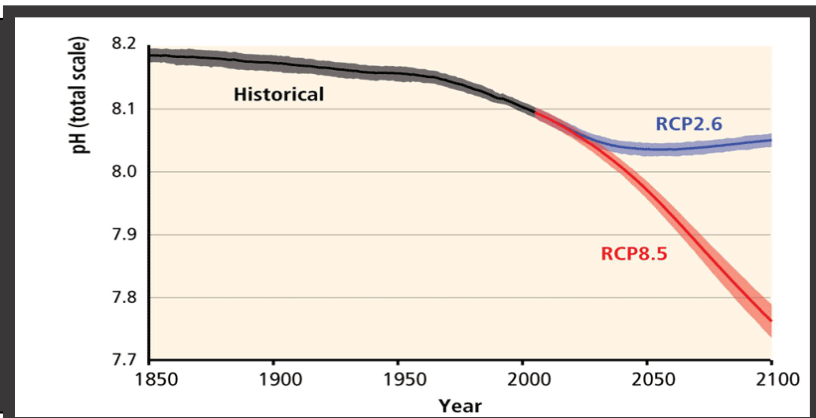
## Case Study 10: Ocean Acidification

Ocean acidification (OA) refers to changes in seawater chemistry as a result of increases in concentrations of the dissolved anthropogenic (human-emitted) CO<sub>2</sub> absorbed from the atmosphere. There has already been an increase in ocean acidity of 26% since preindustrial times, with a 170% increase predicted by 2100 if human CO<sub>2</sub> emissions continue to increase at their current rate. Under the current CO<sub>2</sub> emission trajectory, warming and acidification is likely to result in significant alterations of our marine ecosystems.

### Impact of Future Climate Change Projections

Acidification, or the reduction in pH, leads to an increasing difficulty in the formation of calcium carbonate shells and support structures by some calcifying organisms. Responses of marine organisms are species-specific but include reduced calcification, reduced rates of repair and weakened calcified structures in calcifying organisms like corals, molluscs and crustaceans.

*The graph shows the global mean ocean surface pH from 1850 to 2100, from climate models and shows an overall decrease of about 0.1 pH units (black). Projections up to 2100 are shown for high emission scenarios (red) and low emission scenarios (blue)<sup>28</sup>.*



The Irish shellfish aquaculture industry plays an important role in the Irish coastal economy. Commercially important farmed shellfish such as mussels and oysters may be at risk from OA and increased ocean temperatures. Larval stages are particularly sensitive and in recent years OA, superimposed on already low pH upwelled waters, has been implicated in high mortalities in oyster hatcheries in the US Pacific Northwest. Further investigations are required to determine the implications of OA for Irish shellfish aquaculture. Monitoring OA in coastal waters is complex since changes in pH are influenced by a multitude of drivers including inputs from rivers (e.g. nutrients), biological activity, upwelling, as well as CO<sub>2</sub> emissions.

Cold water corals are deep water reef structures that support a rich biodiversity that are vital to fisheries, but which are particularly vulnerable to OA. The Rockall Trough hosts an array of these structures interacting with a range of water masses along the Irish continental margin. The Rockall Bank and Porcupine Bank areas provide a natural laboratory to study the effects of OA on deep water coral ecosystems.

<sup>28</sup> Gatos et al. 2014

It has been reported that OA can alter sensory systems and behaviour in fish. In order to assess trends in OA and distinguish between natural and anthropogenic changes over time there is a need to establish high quality, long term monitoring of the carbonate system in marine waters. This will provide information on how our marine environment is changing and the potential impacts on our marine ecosystems.

### Steps Towards Building Resilience

Effective management and adaptation strategies in relation to ocean acidification will be limited due to the gaps in our understanding of the spatial and temporal variability of carbon (the cause of OA) in Irish marine waters. The establishment of a long-term monitoring programme of marine carbonate chemistry is essential for Irish coastal, shelf and offshore waters in order to track the underlying changes due to OA and to determine the vulnerability of local ecosystems to those changes. Measures may include:

#### Measures may include:

- Provide support to continue a marine carbon time series across the Rockall Trough to determine rates of OA.
- Monitor and assess marine carbon chemistry, particularly in the vicinity of the cold water corals along the Irish continental shelf, Rockall and Porcupine banks.
- Provide support to continue the winter marine carbon time series in Irish coastal waters to determine the temporal variability of OA parameters and distinguish between natural and anthropogenic changes with time.
- Establish a network of long term baseline monitoring stations in coastal waters to detect seasonal and temporal changes in marine carbonate chemistry to provide information on how Irish marine ecosystems could be affected by OA.
- Identify the least and most vulnerable coastal waters to future OA through on-going monitoring.
- Prediction studies on the responses of Irish shellfish species to future OA.
- Require all future shellfish aquaculture to account for potential future vulnerability.

#### Positive Outcomes:

- Increased understanding of the scale and variability of OA in Irish waters with spatial and temporal trends in OA parameters.
- Baseline datasets of OA parameters at shellfish growing locations to determine the potential threat from future OA on various life stages.
- Baseline datasets for ecosystem studies to determine the potential threat of future changes in OA.
- Extended time series would provide information for climate projection models for future acidification and climate change.

#### Possible steps towards adaptation through building resilience:

- Reduce the vulnerability of the communities that depend on shellfish aquaculture using projected scenarios that include data from ongoing monitoring.
- A number of adaptation strategies are being explored which aim to restore healthy chemistry in the vicinity of vulnerable ecosystems or aquaculture sites; e.g. buffering sediments in shellfish beds with recycled shell hash, cultivating seagrass to protect nearby larvae by absorbing CO<sub>2</sub>, harvesting macroalgae in offshore waters or selective breeding of certain shellfish species which may have greater resistance to low pH waters. These strategies, however, are in their infancy and will be largely governed by the local conditions and will rely on on-going monitoring and extended datasets of OA parameters in the vicinity of vulnerable ecosystems.



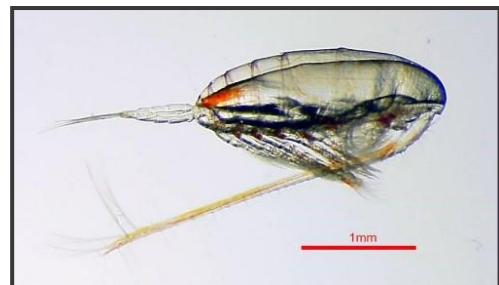
## Case Study 11: Ocean Plankton

**Plankton** are a diverse collection of organisms that drift in the oceans and are a crucial source of food for many species of animals including fish and whales. **Phytoplankton** are microscopic plants that inhabit the upper layer of the ocean. Through the process of photosynthesis they produce organic compounds that form the basis of the marine food chain. **Zooplankton** are small planktonic animals that are an important component of the plankton community and include crustaceans and the eggs and larvae of fish species. As many zooplankton species are important grazers of phytoplankton, they represent the first stage of transferring organic matter to those further up the marine food chain.

### Impact of Future Climate Change Projections

Increased sea temperature and ocean acidification in a changing climate will have far reaching impacts on planktonic species at the base of the **marine food chain**. Zooplankton are particularly vulnerable to climate change induced seawater temperature changes and alterations to oceanic currents. The effect on the zooplankton communities of the NE Atlantic has been subtle with alterations in composition, abundance and distribution in the region. The northward movements of small crustaceans observed at an average rate of 20 km per year, reflects the northward movements of warm water plankton species and poleward retreat of cold water plankton species.

In the North Atlantic, declines in important cold water zooplankton species (copepod *Calanus finmarchicus*) and its replacement by a warm water species (*Calanus helgolandicus*) during spring to late summer have been observed. This had negative consequences for cod and Atlantic salmon, which during their juvenile stage rely on *C. finmarchicus* as a key food source. In Irish waters, a shift towards an earlier presence of *C. helgolandicus* in the Celtic sea, and an earlier decline during the autumn and winter months between 1960 and 2006 has been observed.



*Calanus finmarchicus* (Photo - Dag Altin BioTrix)

Larval stages of marine organisms including economically important species of fish, crustaceans and shellfish are also vulnerable to the effects of climate induced warming seas, alteration to coastal currents, increased turbulence, and acidification from increased atmospheric CO<sub>2</sub>. Changing volumes of phytoplankton and the seasonality of blooms can have cascading effects through the marine food chain, resulting in insufficient food, or a seasonal mismatch of prey for the developing larvae. Juvenile marine organisms can also be vulnerable to changes in temperature, salinity and pH, and larvae may be sensitive to elevated temperatures that their adult stages are able to survive.

Jellyfish are a group of zooplankton that are highly adaptable and can form large aggregations in response to favourable environmental conditions such as warm water or abundance of prey. In the upper waters in oceanic areas, gelatinous zooplankton has been strongly linked to temperature and the presence of copepods. In 2005 in Dublin, blooms of the dangerous ‘Lion’s Mane’ jellyfish resulted in tourism impacts to the beaches around Dublin where people were afraid to swim in the water; in particular ‘open water swimming’ as part of triathlons was affected. In Glenarm, Northern Ireland an entire fish farm’s stock of salmon, worth £1 million was destroyed by large swarms of jellyfish. These and other reported swarms of jellyfish are a potential result of environmental/climatic change and may be an early ecological response to ocean warming.

## Steps Towards Building Resilience

### Actions required:

- Implement long term monitoring of Essential Climate Variables including zooplankton distribution and seasonality and provide increased support for Irish research groups in the area of Zooplankton ecology.
- Facilitate structured and sustainable zooplankton scientific research activities through the implementation of collaborative national multidisciplinary programmes to better inform policy and decision making.
- Participation in international zooplankton and climate research initiatives over decadal timescales to transcend the limitations of short-term research programmes and projects.
- Engage in active ‘co-development’ with sectors likely to be affected such as aquaculture, fisheries and tourism to ensure outcomes meet the needs of these end users.

### Positive Outcomes:

- Results from these actions should help us to plan effective and anticipatory adaptive responses to the impacts of changing climate conditions on marine zooplankton which are now unavoidable, or better anticipate and prepare for those that can be avoided.
- Socio-Economic benefits include avoiding negative impacts to the fisheries, aquaculture and tourism sectors and potential to benefit from penetration of new warm water species.

### Possible steps towards adaptation through building resilience:

- Provide end user needs driven information from research activities to give the tourism, aquaculture and fishing industry time to prepare for, and potentially adapt to, the impact of changes resulting from altered zooplankton communities on a range of timescales.
- Investigate the economic potential for future species of fish and shellfish that may replace existing stocks.
- The FAO recently stated that countries and communities will have to adapt to climate change uncertainty, complexity and risks in fisheries and aquaculture management, governance, markets and livelihoods. This adaptation is a “process of adjustment in ecological, social, or economic systems to actual or expected climate and its effects”, which includes actions that moderate, avoid harm or exploit beneficial opportunities.
- Investigations into avoiding human and other marine organisms injuries from stinging gelatinous zooplankton e.g. jellyfish.
- Investigate aquaculture potential of different species of fish and shellfish that may perform better in the presence of altered zooplankton communities.

## Case Study 12: Seafood Infrastructure

The Irish coastline is a highly utilised and economically active area featuring many high priority industries such as aquaculture, fisheries and tourism. According to figures from the 2016 Census, approximately 1.9 million people or 40% of the Irish population reside within 5km of the coast.

The Irish seafood sector was worth €1.25 billion in 2018. It supports the economic viability of many rural coastal communities, directly generating or supporting approximately 14,000 jobs (direct and indirect employment). This sector is supported by infrastructure such as the 6 designated Fishery Harbour Centres (FHC) and smaller local authority piers and harbours around the coast of Ireland. Rural coastal communities are highly dependent on this coastal infrastructure for access, amenity, as well as a means of earning a living.

### Impact of Future Climate Change Projections

Our coast is affected by events such as storms, surges, and flooding, which are likely to become more extreme in a changing climate and exacerbated by rising sea level. With an increase in extreme storm events likely, together with the rise in sea level, events such as occurred in the winter of 2013-14, which was the stormiest winter on record in Ireland, are set to increase in frequency and have a significant impact on this infrastructure and on our coastal communities.

Against this backdrop it is clear the country must take steps to increase its resilience against the likely impacts of climate change, particularly in highly vulnerable and economically important coastal areas.



*Castletownbere FHC with proposed breakwaters improving shelter in a changing climate.*

Any change to the already hostile environment in which the fisheries and aquaculture industries operate is likely to have considerable impact on the seafood sector. Extreme events result in damage to seafood infrastructure such as small harbours and landing places, aquaculture structures such as fish pens, difficulties in harvesting, increased risk of farmed fish escaping into the wild populations and access problems together with a further increase in risk to those who work in these sectors.

Extremes in weather could result in smaller fishing vessels being prevented from operating for much of the year or being damaged while in port with the resulting loss in income. Sea level rise may affect the future operability of harbours and the suitability of some coastal regions for intertidal aquaculture. Changes in rainfall patterns and extreme rainfall and drought events can impact on inland aquaculture facilities, which supply juvenile stock to the marine aquaculture sector and can cause increased sedimentation and consequent siltation of harbours.

## Steps Towards Building Resilience

### Actions required:

- Development of an integrated ocean observing system to provide real-time data to support recreational users, navigation and commercial activities, tidal predictions, flood warning and long term sea level variability data, including remote sensing capacity to support and augment the observation infrastructure and extend local in-situ observation to basin scale.
- Development of high resolution coastal wave model for all Irish waters to provide more accurate forecasts on a range of timescales and establishment of national flood forecasting capability and ensure adequate warning and protection for coastal communities and seafood infrastructure.
- Ensure assessment of Seafood-related public funding applications considers impacts of climate change taking sea level rise, increased wave heights, forces and storm surges into consideration.
- Ensure all Seafood Infrastructure, including harbours, piers, marine and inland aquaculture facilities are capable of dealing with gradual climate change and extreme weather events by raising awareness and ensuring facilities are adequately designed and maintained.
- Develop a register/database of Climate Change related events or incidents for Seafood Infrastructure, including storm damage, flooding, and aquaculture-related events to allow for informed policy and decision making.

### Positive Outcomes:

- Enhanced protection of citizens, national infrastructure and economically important industries.
- Improved Seafood Industry Infrastructure in place to meet future climate change challenges.
- Advancing ocean observations and monitoring will allow for more informed impact and adaptation planning for those sectors and end users most at risk.



- Improved provision of high quality information, to drive effective policy and decision making, reducing economic and societal impact of both extreme events and longer term changes.
- Improved observation and forecasting capability within a coordinated national framework will reduce the economic and social impact of extreme events such as storm surge and coastal flooding.
- Continued contribution to international climate observation and modelling.

**Possible steps towards adaptation through building resilience:**

- High quality, evidence-based and informed policy and decision making, and impact and adaptation planning, co-developed with relevant end users and stakeholders on a range of timescales.
- Commitment to a sustained and developing observation and monitoring infrastructure to adequately support effective impact and adaptation planning.
- Promotion of coordination between all relevant Departments, state agencies, local authorities and other key stakeholders to address the risks of a changing climate in Irish coastal waters.
- Promote discussion and collaboration between owners and users of Seafood Infrastructure through forums such as Harbour Users Forums, Co-ordinated Local Aquaculture Management Systems (CLAMS) and industry workshops to allow for adaptation to be developed.
- Improved engagement and co-development of needs driven Seafood adaptation plans with end users and stakeholders at risk from climate change impacts.
- Active engagement with the European and wider international community for knowledge exchange, capacity building and to contribute to global goals on monitoring climate change. This will also help maximise the impact of national investments in this area.

## Case Study 13: Tillage

Ireland is a predominately livestock country with 81% of agricultural area devoted to grassland. In 2017, 270,000 hectares were devoted to cereals which accounts for approximately 6% of total agricultural area. Despite this relatively small area tillage remains a key cog in the Irish agri-food sector and is an important supplier to the animal feed, food and beverage sectors. The sector is also an important source of straw for the livestock and mushroom industries in addition to having a modest but important seed sector.

Weather can significantly impact on tillage systems as was clearly exhibited in 2018 with the late Spring pushing back sowing dates and in many cases sowing windows being missed for some crops. The drought conditions that followed severely impacted on grain and straw yields of Spring crops in particular. These extreme weather events in 2018 clearly flag the potential impacts of future extreme weather events arising from climate change and how production and hence profitability/viability of the sector can be impacted. While there are threats to the sector there are also opportunities that have arisen such as contract growing of crops such as maize between tillage farmers and dairy farmers to the benefit of both parties. In the future the potential to introduce new crops or to increase the areas of some existing crops is seen as an opportunity.

### Impact of Future Climate Change Projections

In relation to extreme temperatures and heat waves, warming is projected to be enhanced with highest daytime temperatures in the warmest 5% of daily maximum summer temperatures projected to rise by 0.7°C to 2°C for the medium to low emissions scenario and from 1.3°C to 2.6°C for the high emissions scenario. The number of dry periods (at least 5 consecutive days for which the daily precipitation is less than 1mm) is projected to increase substantially by mid century during summer by 12% to 40%. With regard to rainfall, it is expected that there will be increases of 14% in winter precipitation with a decrease of 20% in summer precipitation. However, extreme storm events will decrease over the winter but their intensity is projected to increase.

*Tillage Farmers<sup>29</sup>*



<sup>29</sup> <https://www.independent.ie/business/farming/teagasc-urge-tillage-farmers-to-consider-machinery-partnerships-34227102.html>

In 2018 the resultant impact of the extreme weather events was a substantial decrease in cereal production of 23% as a result of decreased area and reduced yields. Spring crop grain yields were very adversely affected as a result of late sowing and particularly drought throughout the growing season. Straw yields were also adversely affected in spring crops. Such events can be dealt with by having more robust varieties to deal with extended periods of drought and incorporating drought tolerance traits into new varieties arising from plant breeding programmes. In addition, shorter or later sowing windows will necessitate large output machinery (including possibility of min-till to reduce field operations and hence increase sowing capacity) in order to sow crops in good conditions.

The tillage sector currently supplies approximately 40% of raw materials used in the animal feed sector in a normal year (2018 excluded). The effect of low yields on the income and profitability of primary producers is severe especially given continuously high production in the main grain producing regions worldwide which impacts negatively on Irish Growers. In addition, such extreme events can result in specifications for primary producers supplying high value niche markets such as barley for malting not being met as happened with a proportion of the crop in Ireland in 2018.

## Steps Towards Building Resilience

Identifying adaptation measures that address some of the risks identified will be key.

### Actions included:

- The expected Irish climate is expected to be similar to the current climate in South East England and North West France, therefore many lessons can be learned from current practices in these areas and adapted to Irish conditions.
- Conversion of land currently in grass where grass growth is predicted to be negatively affected to cereals and other crops that have better ability to deal with drought.
- Continued monitoring for new pests, diseases and weeds is a threat while some existing pests, diseases and weeds may no longer be an issue.
- Ongoing Value for Cultivation and Use (VCU) trials conducted by DAFM over 3 years to identify robust varieties with the ability to deal with the extremes of climate change.
- Investment in Research such as the VICCI (Virtual Irish Centre for Crop Improvement) whereby traits identified as being crucial to dealing with future climate change challenges are identified in genetics of various species. These traits will then be made known to breeding companies based abroad with a view to them using this information in breeding new varieties suitable to the Irish Climate.
- Continued investment in Research and Knowledge Transfer with an emphasis on measures to counteract the challenges of climate change, e.g. using adapted crops/crop varieties, crop husbandry, irrigation, Integrated Pest Management (IPM), increased output machinery, soil erosion prevention and increased crop diversification to spread risk.
- Development of other risk management strategies including voluntary insurance schemes under the Common Agricultural Policy (CAP).
- Opportunities include increased potential for increased areas of crops currently accounting for limited areas such as Peas and Maize especially in geographic areas not currently climatically or commercially suitable for these crops.

## Case Study 14: Water in Agriculture

As custodians of the environment the farming communities in Ireland have an integral role in securing a healthy environment which can support their economic activities. Due to the importance of agriculture in the National economy it contributes significantly to national GHG emissions. As such, the sector as a whole, and in particular the livestock and forestry sectors are working to mitigate their impact on climate change while in parallel developing tools to adapt to climate change. Water resources are of concern in all climate change discussions, both cause and effect, and are particularly critical in the context of Irish agriculture. Research based mitigation measures are continually being developed and implemented. Here the discussion focuses on the challenges climate change imposes on water resources for the agriculture and forestry sectors.

### Impact of Future Climate Change Projections

Globally water resources are directly and indirectly affected by changes in weather patterns. In recent years Ireland has experienced prolonged and more frequent periods of drought, flooding, extreme temperatures and weather events which have taken a heavy toll on lives and livelihoods in rural Ireland.

Taking the extreme weather events of 2018 as an example we can see the range of extremes that require some adaptation to for the future. The prolonged extreme dry summer severely restricted water supplies across the country resulting in farmers having to seek out alternative sources of water for livestock and on-farm activities. Other significant effects of this warm period included: animal stress and disease pressure, in some cases the availability of water, farm safety compromised, fodder shortages, compliance difficulties with EU Nitrates Directive regarding slurry storage and land spreading, irrigation pressures, and altered soil quality.

The on-farm capacity to source, store and deliver safe water on farms will need to become an integral part of management planning. Slurry storage will need to be reassessed for capacity during extreme weather events. Water management on national/regional/local level needs to be integrated further in the context of physical and logistical adaptation measures for water in agriculture during both drought and flood events.

### Steps Towards Building Resilience

Clearly, a collaborative and coherent adaptation plan is required to minimise disruption in output from the agriculture and forestry sectors while meeting environmental standards.

#### Actions may include:

- Weather extremes may largely offset baseline nutrient concentrations, enhance nutrient loads and alter the type of nutrient loss risk. Strategies to mitigate nutrient loss need to consider the effects of both long-term climate changes and the short-term weather extremes. Targeted mitigation or adaptation measures and knowledge transfer will be



important to overcome some of these challenges.

- DAFM supports schemes such as Agricultural Catchments Programme (ACPs), Smart Buffers for riparian zones, the Sustainable Dairy Assurance Scheme and the Agricultural Sustainability Support and Advice Programme (ASSAP) which aim to protect and enhance water resources. The ASSAP is an initiative funded by DAFM and DHLG with support from the dairy industry and will employ 30 Advisors to work within a unified partnership structure which encompasses Teagasc, the Co-ops and LAWCO - the local authorities Water and Communities Office. The new Sustainability Advisors will proactively advise and work with farmers to protect and improve water quality. The findings and recommendations of these schemes will inform decisions around agricultural activities that may impact water quality. These decisions and resulting environmental measures must then inform adaptation measures to secure the critical resource.
- Forests plays an important role here too. Properly sited and managed forests can themselves play an important role in protecting and enhancing water quality and aquatic ecosystems through the delivery of a range of water-related ecosystem services however such adaptation strategies must be clearly planned and aligned.

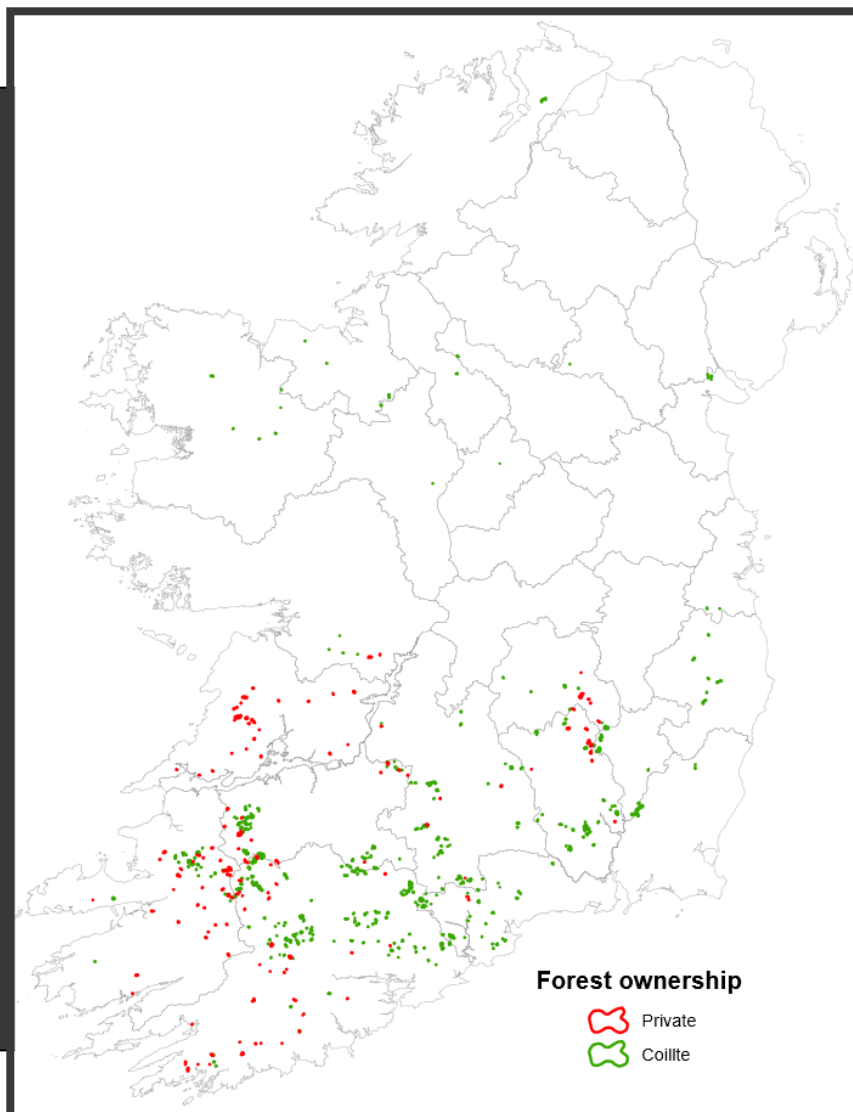


*ASSAP – Agricultural Sustainability Support and Advice Programme<sup>30</sup>*

<sup>30</sup> <https://www.teagasc.ie/environment/water-quality/farming-for-water-quality-assap/assap-in-detail/>

## Case Study 15: Windthrow and Forests

A National Windblow Task Force was set up following Storm Darwin in February 2014. Part of the Task Force's work was to conduct a rapid assessment of wind damage to Irish forests across the Estate (both public and private). The RapidEye satellite constellation was chosen for the acquisition of post-storm image data as it was the most cost effective and flexible data source to map the spatial extent of the wind damage in Irish forests (both public and private). The satellite image data were analysed using a supervised classification. The digital wind damage map generated by the consortium, demonstrated the effective use of remote-sensing for the collection of windstorm forest damage data in Ireland. Within 8 weeks of data delivery, the consortium concluded that at that time, over 8,000 ha of forests were damaged by the storm, approximately 6,000 ha of state forests managed by Coillte Teoranta and a further 2,000 ha forest held in private ownership.



*Distribution  
of damage to  
the forest  
estate  
following  
Storm  
Darwin,  
February  
2014<sup>31</sup>*

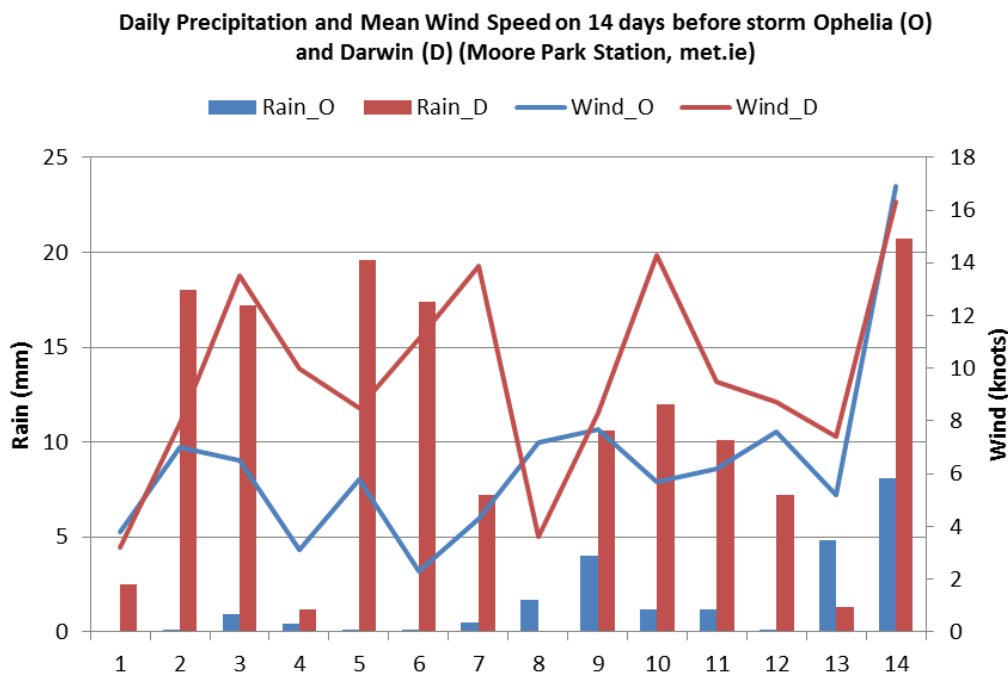
<sup>31</sup><https://www.agriculture.gov.ie/media/migration/forestry/forestservicgeneralinformation/Annual%20Forest%20Sector%20Statistics%202014.pdf>

## Impact of Future Climate Change Projections

Recent years have seen a number of major storm events and forests and trees can be particularly vulnerable to their impact. The extent of wind damage is dependent not just on the peak wind speeds but also on the weather preceding it. It is likely that the increase in the occurrence of extreme rainfall events and severity of winter storms associated with climate change will increase the incidence of windblow especially as the private estate in Ireland matures. Increased waterlogging and delayed thinning and inappropriate thinning practices (incorporation of brown edges for timber stacking) may increase the risk of forest damage. Tree species, soil type and drainage are also important factors in determining the vulnerability to wind damage. This can be highlighted when comparing the impacts of two recent storms, Ophelia in October 2017 and Darwin in December 2014. While both storms recorded similar maximum wind speeds, Darwin was preceded by two weeks of heavy rainfall and high average winds. These conditions can weaken tree roots and leave forests highly vulnerable to windblow and would have contributed to the significant area of forest that was damaged during the storm. Conversely rainfall before storm Ophelia was limited and the mild weather at this time and timing of the event meant that many broadleaf trees were still in leaf providing a wider area for the wind to act against. Anecdotally this resulted in more mature broadleaf trees being uprooted, including in urban areas.

## Steps towards building resilience

DAFM has funded the development of a Windthrow model for Ireland and a number of research projects that have provided information to forest owners on managing windthrow risk. For example, Ni Dhubhain and Farrelly (2018)<sup>32</sup> outline a range of actions that can be taken to reduce the risk of windthrow. These include management strategies incorporating appropriate forest planning, cultivation, establishment, thinning/spacing and suitable rotation lengths.



<sup>32</sup> <http://www.coford.ie/media/coford/content/publications/2018/SM23ManagingWindthrow160418.pdf>

## APPENDIX II - ADAPTATION IMPLEMENTATION PLAN

### Action 1: Mainstream climate change adaptation planning across the Department through development and implementation of a composite adaptation plan for the agriculture, forest and seafood sector

| Steps for delivery   | Timeline by quarter | Lead authority and stakeholders |
|--|---------------------|---------------------------------|
| Engage internal adaptation stakeholder group with representatives from across the Department to champion adaptation issues | Ongoing             | DAFM                            |
| Publish adaptation Plan for the agriculture, forest and seafood sector   | Q4 2019             | DAFM                            |

### Action 2: Work collaboratively with agencies and other departments to develop national policy supporting climate change adaptation and maximising synergies with mitigation

| Steps for delivery   | Timeline by quarter | Lead authority and stakeholders                      |
|--|---------------------|--|
| Actively participate in National Adaptation Steering Group   | Ongoing             | DCCA, DAFM   |
| Actively engage with other sectors developing adaptation plans to ensure coherence of cross-sectoral interdependencies     | Ongoing             | DAFM   |
| Identify areas of cooperation with other key external stakeholders including opportunities for data sharing across sectors | Ongoing             | DAFM, other Government Departments and agencies, LAs |



**Action 3: Engage with the Common Agricultural Policy (CAP) review to ensure environmental objectives related to climate change mitigation and adaptation are adequately covered in the post 2020 CAP**

| Steps for delivery  | Timeline by quarter | Lead authority and stakeholders |
|---|---------------------|---------------------------------|
| Input to CAP Strategic Plan development   | Ongoing             | DAFM                            |
| Prepare Environmental SWOT analysis   | Q4 2019             | DAFM                            |
| Consideration of climate sensitivities as part of next Common Agricultural Policy | Ongoing             | DAFM                            |

**Action 4: Engage with the implementation process of the national policy statement on the bioeconomy to ensure climate change mitigation and adaptation are mainstreamed into bioeconomy implementation**

| Steps for delivery  | Timeline by quarter | Lead authority and stakeholders   |
|---|---------------------|---|
| DAFM to co-chair the Bioeconomy Implementation Group  | Ongoing             | DAFM and DCCA, DOT, DBEI, DHPLG, DTTAS, DPER, DFIN, DRCD, DCHG, EPA, EI, NESC, Teagasc, SFI, SEAI |
| Ensure climate change mitigation and adaptation are mainstreamed into bioeconomy implementation | Ongoing             | DAFM  |

**Action 5: Identify current and potential vulnerabilities in the sector to climate variability and extreme events**

| Steps for delivery | Timeline by quarter | Lead authority and stakeholders |
|--------------------|---------------------|---------------------------------|
|--------------------|---------------------|---------------------------------|

|  |         |      |
|--|---------|------|
| Review Impact and Vulnerabilities assessment on a periodic basis | Q4 2021 | DAFM |
|--|---------|------|

**Action 6: Greater integration of adaptation issues into agricultural syllabuses at colleges, third level institutes and CPD courses**

| Steps for delivery  | Timeline by quarter | Lead authority and stakeholders |
|---|---------------------|---------------------------------|
| Engage with third level education institutes to review provision of course and module programmes related to agriculture and land use                          | Q4 2019             | IUA, THEA, DAFM, Teagasc        |
| Outcomes of relevant research programmes to be incorporated into all knowledge transfer programmes/ advisory programmes including Teagasc ConnectED Programme | Ongoing             | DAFM, Teagasc, ACA              |

**Action 7: Up skill farmers, foresters and fishermen to ensure they have the knowledge and tools required to implement climate adaptation practices**

| Steps for delivery  | Timeline by quarter | Lead authority and stakeholders          |
|---|---------------------|--|
| Promote tools that support adaptation decisions such as Climadapt                             | Ongoing             | DAFM and Agencies                        |
| Incorporate climate adaptation and resilience building as part of knowledge transfer programs | Ongoing             | DAFM, Teagasc and Advisory Services, ACA |

|   |         |   |
|---|---------|---|
| Include climate adaptation information in relevant workshops and events | Ongoing | DAFM, Marine Institute, Bord Iascaigh Mhara, Teagasc, Coillte |
|---|---------|---|

**Action 8: Continue support for focused climate related research in the agriculture, forest and seafood sector**

| Steps for delivery   | Timeline by quarter | Lead authority and stakeholders |
|--|---------------------|---------------------------------|
| Establish a sub-group of the Adaptation Stakeholder Group to consider adaptation research prioritisation exercise  | Q3 2020             | DAFM, Teagasc, Coillte          |
| Incorporate climate adaptation and resilience building into all relevant research programmes   | Ongoing             | DAFM, Teagasc                   |
| Prepare proposal on impact of climate change on hosts, disease, pests and pathogens building on previous DAFM funded research  | Ongoing             | DAFM, Teagasc                   |
| Further research on economic modelling of climate impacts to raise awareness of need for financial resilience against impacts of climate change  | Ongoing             | DAFM, Teagasc                   |
| DAFM's Research Programmes have a significant role to play in identifying possible threats to the agriculture, forest and seafood sector due to climate change and providing solutions through research ensuring stability of production and identifying possible areas of expansion | Ongoing             | DAFM, Teagasc, Marine Institute |

|  |                 |                        |
|--|-----------------|------------------------|
| Research programmes supporting impact and adaptation studies.                  | Commencing 2019 | DAFM, Marine Institute |
| Research into Climate/Ocean Change and the distribution of fish and fisheries. | Ongoing         | DAFM, Marine Institute |

**Action 9: Engage with industry to support the sector in building resilience in their systems and practices**

| Steps for delivery   | Timeline by quarter | Lead authority and stakeholders               |
|--|---------------------|---|
| Engage with industry to support farmers and foresters in building resilience and ensure their own resilience to potential climate impacts                        | Q4 2020             | DAFM, Industry                                |
| Work with industry to develop long-term management measures for inshore fisheries to support adaptation by managing exploitation patterns on a sustainable basis | Ongoing             | DAFM, Bord Iascaigh Mhara<br>Marine Institute |

**Action 10: Raise awareness among external stakeholders on climate change and adaptation issues**

| Steps for delivery  | Timeline by quarter | Lead authority and stakeholders |
|---|---------------------|---------------------------------|
| Incorporate climate adaptation material into information material to be used at | Ongoing             | DAFM                            |



|   |         |                         |
|---|---------|-------------------------|
| Departmental events   |         |                         |
| Develop a roadmap to ensure the future development of the agriculture, land use including forest sector will be built upon environmental sustainability | Q4 2019 | DAFM, Teagasc, Bord Bia |

**Action 11: Support the sector and foster sustainable growth, development, innovation and adaptation including through LIFE, HorizonEurope, the European Maritime and Fisheries Fund and CAP funding**

| Steps for delivery   | Timeline by quarter | Lead authority and stakeholders |
|--|---------------------|---------------------------------|
| Seek to adapt on-farm practices to enhance sustainable agricultural production   | Ongoing             | DAFM, Teagasc                   |
| 40% of the overall CAP budget to contribute to environmental or climate action.  | Q2 2020             | DAFM, D. Finance                |
| Analyse and explore options for availing of financial risk-management tools including through market tools such as insurance to be considered in context of the next CAP | Ongoing             | DAFM                            |
| Continued funding of projects concerning knowledge innovation and technology which are relevant to climate change adaptation   | Ongoing             | DAFM                            |
| Facilitate schemes which improve the sustainability of the seafood catching, farming and processing sectors  | Ongoing             | DAFM, Bord Iascaigh Mhara       |

**Action 12: Raise awareness of health and safety issues arising for those working in the sector particularly at primary producer level**

| Steps for delivery  | Timeline by quarter | Lead authority and stakeholders |
|---|---------------------|---------------------------------|
| Continue to work with the HSA on farm safety issues                               | Ongoing             | HSA, DAFM                       |
| Provide basic and enhanced safety training courses to improve safety at sea       | Ongoing             | DAFM, BIM                       |
| Completion of Risk Assessment and Policy Statement (Safety Statement) for vessels | Ongoing             | DAFM, BIM                       |

**Action 13: Greater awareness of OPW flood risk mapping to inform decision making**

| Steps for delivery  | Timeline by quarter | Lead authority and stakeholders |
|---|---------------------|---------------------------------|
| Engage with OPW flood maps to identify the areas of land / floodplain that are expected to be inundated in context of next Nitrates Action Programme review | Q4 2022             | OPW, DAFM                       |

**Action 14: Build internal capacity by engaging in knowledge sharing and information exchange to increase awareness of climate and adaptation issues across the Department and its agencies**

| Steps for delivery                                     | Timeline by quarter | Lead authority and stakeholders |
|--|---------------------|---------------------------------|
| Build internal capacity through development of climate | Q2 2020             | DAFM                            |

|   |          |   |
|---|----------|---|
| awareness training programme                              |          |   |
| Raise climate awareness through internal staff newsletter | Annually | DAFM                                      |
| Network with our agencies to build capacity               | Ongoing  | DAFM, Bord Bia, Teagasc, Coillte, BIM, MI |

**Action 15: Promote adaptation screening as part of Department policy development**

| Steps for delivery                                    | Timeline by quarter | Lead authority and stakeholders |
|---|---------------------|---------------------------------|
| Develop adaptation impact screening analysis document | Q1 2020             | DAFM                            |

**Action 16: Review and update sectoral Adaptation Plan at least every five years**

| Steps for delivery  | Timeline by quarter | Lead authority and stakeholders |
|---|---------------------|---------------------------------|
| Complete Adaptation Plan for the Agriculture, Forest and Seafood Sector | Q3 2019             | DAFM                            |

## APPENDIX III – ENGAGEMENT

### Cross-Sectoral (across all 3 DAFM Sectors) engagement has included:

- Under the 2012 [National Climate Change Adaptation Framework](#), relevant Government Departments, Agencies and local authorities were requested to prepare sectoral and local adaptation plans. As part of this framework the Department of Agriculture, Food and the Marine (DAFM) prepared a non-statutory Climate Adaptation Planning document for the Agriculture and Forest Sector which included a public consultation workshop and open consultation period; all of which contributed to raising the profile of climate impacts in the sector. Additionally DAFM held a preliminary public consultation on the preparation of a Marine Sector Low Carbon Roadmap, in December 2013.
- An agriculture, forest and seafood **Cross Sectoral Seminar** took place on 20 March. Approximately 60 people attended the event. There was a wide range of presentations including: Flood Risk Management by the Office of Public Works, Biodiversity by the National Parks and Wildlife Services and a presentation by the Marine Institute, Teagasc and a representative of the forest sector. A panel discussion on priority cross sectoral interactions took place involving DAFM, DHPLG, NPWS and OPW reps.
- The public consultation which ran from 27 June to 16 August 2019 provided another means of stakeholder engagement and was advertised in the agri supplements of two national newspapers, on the [Department website](#), [Gov.ie](#) and on specialist websites such as the Inshore Fisheries Forum and Our Ocean Wealth. The adaptation plan also received media coverage in the Skipper. Furthermore, stakeholders were invited to the launch of the public consultation on 27 June 2019. 49 submissions were received prior to the closing date and three submissions thereafter. The main points raised are addressed thematically in the Consultation Report of the revised Plan.

### Other stakeholder engagements included:

- DAFM had a presence at the **Sea-Fisheries Protection Authority (SFPA) Breakfast Events** throughout 2019. A leaflet on [“Climate Change Adaptation Planning for the Seafood Sector”](#) was distributed at these events.
- **The Skipper Expo**, Galway, 8 & 9 March 2019 – The “Climate Change Adaptation Planning for the Seafood Sector” leaflet was available on the DAFM stand at the Skipper Expo.
- **Seafest**, Cork City, 7-9 June 2019 – The Marine Institute hosted a Climate Adaptation Stand at Seafest to showcase the preparations underway and the Seafood Climate Adaptation case studies booklet was distributed to interested parties.
- The issue of global climate change was highlighted at **Our Ocean Wealth Summit**, 10 June 2019, in Cork.
- The Seafood Climate Change page of the DAFM website has been kept up to date and the information leaflet is available to view on same.
- An article on “Seafood Sector Climate Change Adaptation Planning” is included in [Harnessing Our Ocean Wealth Review of Progress 2018](#).



- Climate Change Adaptation was raised by DAFM as an agenda item at meetings with industry such as the National Inshore Fisheries Forum in December 2018.
- Representatives from the Marine Institute attend a **Science Industry Partnership** meeting held every quarter; climate change has been highlighted as the number two priority area after Brexit at these meetings.
- An information leaflet on “The Effects of Climate Change on Irish Agriculture” was prepared and circulated at The National Ploughing Championships in 2018.
- Climate Adaptation issues included in presentations to stakeholders including in Farm Advisory Training sessions.
- Climate Adaptation workshop targeted at agriculture advisors in November 2018
- Climate Adaptation was included on the agenda of the Environmental Sustainability Committee which includes representatives from other Government Departments, agencies and academia.
- **Forestry Promotional Implementation Group, Chaired by Minister of State Andrew Doyle (22/7/19)** - DAFM provided an update on the Climate Action Plan and the role of forests in mitigation and adaptation. The Group consists of a wide range of industry and environmental stakeholders and is chaired by Minister of State Doyle.
- **COFORD Council 2019 – 2021** - DAFM have provided a number of updates on the Climate Action Plan to the COFORD Council and on actions which include forest mitigation and adaptation. The COFORD Council is a body appointed by the Minister of State for Agriculture, Food and Marine to advise him and his Department on issues related to the development of the forest sector in Ireland. Its membership is appointed by the Minister of State and comprises stakeholders from across the forestry sector. The current Council is in the process of establishing a working group on Forests, Climate Change Mitigation and Adaptation.
- **Society of Irish Foresters National Forestry National Forestry Conference** - The Society of Irish Foresters National Forestry Conference "Forestry as a Climate Change Solution", examined the role of the Irish forestry and forest products sector in mitigating climate change and reducing green house gas (GHG) emissions. The conference featured Irish and international speakers who addressed the role of the forestry and forest products sector in mitigating climate change and meeting GHG emission targets in collaboration with industry, energy, agriculture and sectors such as construction and transport.
- **Forestry Promotional Events** - In 2019, DAFM has funded fifteen initiatives countrywide to highlight the multifunctional benefits of forestry, promote the planting of more trees and encourage sustainable forest management. The aim is to enable people to feel connected to forests, locally and nationally. The experience will hopefully enhance their feelings of wellbeing and their knowledge of the essential place of forests in our lives, including the benefits of forestry employment, income generation, biodiversity and climate change sequestration. Kerry Event - <http://gortbrackorganicfarm.com/online/index.php/forest-connections/> Leitrim Event - <http://woodlandfestival.ie/>.
- **Wood energy workshop** - DAFM has organised workshops annually on producing quality wood fuels and developing knowledge on the wood quality. The workshops are aimed at anyone with an interest in wood for energy. It is particularly useful for farmers/forest

owners, chipper and boiler manufacturers and suppliers, forest contractors, wood fuel suppliers, consultants etc.

**Post Plan Engagement:**

- Consultation will be held with sector representatives to identify the most effective means of communicating and supporting delivery of the actions set out in this plan.

Department of Agriculture,  
Food and the Marine



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