

Farming for Biodiversity in Leitrim Research and Outreach Project

Project Report

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1. THE PROJECT OBJECTIVES AND OUTCOMES.

The Farming for Biodiversity in Leitrim project is a Leitrim Heritage project being run in partnership with the Leitrim Sustainable Agricultural Group. The Department of Housing, Local Government and Heritage under the Local Biodiversity Action Fund and Leitrim County Council (CoCo) provided the funding.

The project consortium included Leitrim CoCo and the Leitrim Sustainable Agriculture Group (LSAG), formed to promote viable environmentally friendly farming practices on Leitrim farms.

The project aims to support farmers across Leitrim to continue to farm their biodiversity-rich lands while protecting, enhancing, and restoring biodiversity and habitats on their farms.

The four project objectives were:

1. Celebrate farming for nature in Leitrim through the production of a short video.
2. Provide outreach events promoting farming for nature to farmers and the general public.
3. Research and quantify the environmental, social, economic, and cultural value presently provided by small, low-intensive farming in Leitrim.
4. Work with farmers to formulate a methodology to measure ecosystem services on farms in Leitrim.



€19,125 has been granted for Biodiversity Awareness & Education and will see a farming biodiversity project run in partnership with the Leitrim Sustainable Agricultural Group, which will support farmers across the County to protect, enhance and restore biodiversity and habitats.

By **Fiona Heavey**
23 Sep 2022 10:00 AM

This Project Report outlines the outcomes of delivering the project's aims and objectives.

Objective 1 - outcomes

Two videos were produced, Thinking Differently and Leaving Something Behind, showing the passion these two Leitrim farmers have for farming and their pride in the beef and sheep farming systems that define Leitrim agriculture. They discuss some of the changes in thinking required to ensure the viability of Leitrim farming for the next generation.



<https://youtu.be/43lw8OnvIE4>



https://youtu.be/1_nmLaMCRZc

Objective 2 – outcomes

The activities increased the project and consortium's profile within the county and developed an integrated multi-functional vision for Leitrim farming. The project consortium actively engaged with community stakeholders and received their support to work with them in strategising and implementing projects to realise the vision, thereby contributing to the county's economic, environmental, and social future.

The project hosted a webinar as part of National Heritage Week on August 17, 2022. The focus was on the following:

- Creating awareness among the farmers and the broader Leitrim community of the project and Leitrim CoCo's 2022 – 2027 Biodiversity Action Plan. The plan was published in April 2022 to raise awareness of the county's biodiversity and to encourage the public to engage in educational and practical conservation activities.
- Informing farmers about the new ACRES Breifne Project, launched in August 2022, offering them for the first time payments based on the quality of the biodiversity on their farms. It is based on a methodology using scorecards to measure farm ecosystem services and pay for them.

<https://www.youtube.com/watch?v=wIIPtRYm4k&t=303s>

Two **farm walks** were organised to increase awareness of the biodiversity-rich lands and high-quality water resources on Leitrim farms. The walks provided attendees with information about biodiversity and water quality on their farms and discussion opportunities with enthusiastic experts. The walks also created awareness amongst the farming and broader Leitrim community of the project and its new farming vision.

The host farmers welcomed the visitors and described how they operate and their ambitions for the future. The experts for the biodiversity walk included:



- Dr Dolores Byrne, Atlantic Technical University, spoke about the importance and relevance of biodiversity, the history of results-based payments, and some of the unique habitats on the Leitrim uplands. What they are, why they are essential and how they are valued.
- Dr Vicky Veerkamp, a catchment scientist with LAWPRO¹, spoke about the importance of water and the need to protect it.
- John Gallogly, Philip Farrelly & Co. described how the quality of biodiversity is assessed using a scorecard.
- Dr Caroline Sullivan of the ACRES Breifni Cooperation Project explained how this new agri-environment scheme would benefit Leitrim farmers and financially reward them for delivering high-quality ecosystem services.



The experts for the water farm walk included:

- Aileen Owens, a catchment scientist with LAWPRO, provided an overview of Leitrim's generally good water status but pointed out a need for ongoing vigilance by all community members to ensure it is maintained and improved where necessary.
- Karen Kennedy, a Community Water Officer with LAWPRO, emphasised how collaborating with local communities to protect and improve Leitrim's high-quality waters will benefit the community's health, well-being, and heritage and mitigate against climate change.

¹ <https://lawaters.ie/>

- ASSAP advisor Eamonn Avery, spoke about using sprays to control rushes on farms in Leitrim.
- Brendan McKenna, Senior Executive Engineer with Leitrim CoCo and Conor McCarthy of Jennings O'Donovan from Clarkes, described the progress with the exciting new Carrick-on-Shannon to Battlebridge Blueway.

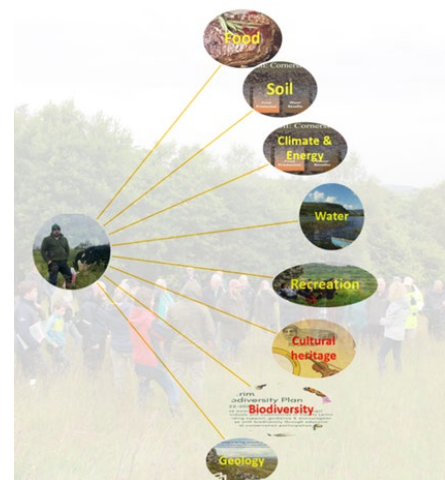


Three **workshops** were organised, two with LSAG members and one for stakeholders and LSAG members.

The **first LSAG workshop** in early August identified the themes for the two videos and farm walks. The implications of the new ACRES Breifni project for project objective 4 were discussed. It was agreed that the introduction of a results-based payment using a scorecard addressed objective 4 - a methodology to measure ecosystem services on farms in Leitrim. Therefore, the focus moved to developing a vision for LSAG and identifying a prioritised list of projects to achieve it. The aim was for the consortium and interested stakeholders to seek external funding to implement new projects.

The multi-functional model was proposed and accepted based on the concept that soils can offer various ecosystem services to complement food production. The farm outputs can also include water supply and flood control, carbon sequestration, biodiversity & habitats, public health, recreation, geology, and cultural heritage.

The model envisages that the low returns from Leitrim's beef and sheep production systems due to soils, demographics and climate can be increased by payments for these new ecosystem services.



These new payments will increase incomes for Leitrim farmers and make them viable. It is worth noting that a recent EU Commission identified low farm profitability as the main barrier to young people taking up a farming career.

The differences in Leitrim's landscape and biodiversity are evident, travelling from south to north. There is no "one size fits all" land management system for delivering ecosystem services. Bespoke management systems, reflecting the capacity of the soils, landscape, and land managers, primarily farmers, are required to provide the most sustainable mix of ecosystem services. The farmers agreed that working with the broader rural community is necessary to deliver and build on any form of a multi-functional farming model for Leitrim.

The **second LSAG workshop** agreed that LSAG needs to put in place more robust governance and communication structures as a priority. It is essential to securing external project funding with Letrim CoCo and other stakeholders.

An outline summary of the project and Consortium vision was presented at the **Stakeholder and LSAG Workshop**. The stakeholders represented water quality, biodiversity, carbon sequestration, cultural heritage and members of the public. The stakeholders responded positively to the LSAG vision, outlined how they might collaborate with the consortium in the future and provided links with the broader non-farming Leitrim communities.

There were two immediate recommendations arising from the three workshops. These were

The consortium should seek funding:

- To provide LSAG members with training that will result in a more robust governance structure to position itself to lead future funding applications.
- To develop and implement a communication strategy that will improve the consortium's and its partner's outreach and, ultimately, their positive impact on the county.

Background notes on both are provided in the Appendix.

Objective 3 - outcomes

Objective 3 was to research and quantify the environmental, social, economic, and cultural value presently provided by small, low-intensive farming in Leitrim under the following headings biodiversity, Carbon Sequestration, Social and Community Value, Local Economy, Health, Local Sustainable Food, Built Heritage.

A project outcome was the emergence of an agreed consortium and stakeholder vision for Leitrim farming – an integrated multi-functional farming model delivering food and more comprehensive ecosystem services. Payments for these services will assist in increasing the viability of farm incomes and provide a basis for underpinning the county's natural resources to make it a great place to live, work and visit. Furthermore, a need was recognised to secure future funding to realise the vision. The level of stakeholder involvement in delivering objectives 1 and 2 provided evidence of the social and community value of Leitrim farming. Therefore, there was a shift in Objective 3 research focus to align itself better with the outcomes from the other project objectives.

Providing background information on the ecosystem services envisioned by the shared consortium and stakeholder vision for developing and implementing a multi-functional farming model. The outcome will provide a source of background material that will assist the consortium, and their potential stakeholders, to inform themselves and assist in preparing the planned future funding applications.

- The role of geology as part of Leitrim's natural heritage. It is the part of nature that is not alive – minerals, fossils, soils, mountains – and the geological processes that have shaped the county's landscape. It is the silent partner to biodiversity, helping to understand the complex connections between the living and non-living worlds. Geodiversity underpins food production, water management and energy production.
- The role of Leitrim's soils and the implications of their suitability and capacity for food production – primarily based on grass.
- An approach was developed to identify the best blend of ecosystem services for individual farms.
- Sixty-three per cent (63%) of Leitrim's monitored rivers (SW 2013- 2018) are classed as high or good, with 22% classed as moderate and the remaining 15% as poor. The status of Leitrim's rivers is better than river status nationally, with 52%, 28% and 19% classified as high and good, moderate, and poor, respectively.
- The 50% reduction in Leitrim's high-quality rivers over the last 10 to 12 years is of concern.
- There are nine areas identified as priority areas for action. In these areas, collaborative efforts will be made over the next six years to protect and restore the declining stock of high-status waters. These lands are included in the Breifni ACRES Cooperation Project zones, and farmers with lands in these areas should join ACRES.
- The role of hedgerows, watercourses, high nature value grassland and peatlands as ecosystem services is outlined. It was concluded that:
 - Increasing biodiversity, particularly wildlife populations, can benefit farmers by improving agricultural productivity.
 - Biodiversity is essential for regulating ecosystem processes and delivering ecosystem services.
 - Farming approaches can be tailored to benefit wildlife and biodiversity, increasing ecosystem stability in the face of environmental change.

- Leitrim's agricultural GHG emissions per ha are **almost half the national** average. It reflects the lower farming intensity associated with Leitrim's soils and smaller farm sizes.
- Management options for Leitrim's wetlands, especially peatlands, require urgent assessment and implementation. Peatland's potential to sequester carbon and offset emissions is particularly relevant to Leitrim.
- Wetland areas for rewetting to reduce emissions and re-start sequestration should be identified, and associated land management programmes should be started. Time is of the essence, as peatland ecosystems will take several years to re-establish and build resilience to projected climate changes. It will involve ceasing turf cutting.
- Adoption and successful implementation of climate change mitigation policy and measures depend on farmers' acceptance based on their lived experience, knowledge and understanding. Additional research and resources to enable effective knowledge exchange are required.
- These mitigation measures are likely to bring multiple co-benefits, contribute to economic, social and environmental sustainability and are associated with essential, good land stewardship.
- Most ecosystem services are public goods and do not have a market value.
- In principle, the valuation process allows us to demonstrate the value people have for natural capital and ecosystem service compared with the other goods and services contributing to their quality of life (*e.g.*, material goods like consumer goods traded in the marketplace).
- Valuing natural capital is far from a simple process and is beyond this project's scope.
- However, the new ACRES Breifne Cooperation Project will use a results-based payment scheme to reward farmers for the quality of their habitats. It represents an initial attempt at valuing ecosystem services using surrogates to quantify the quality of the biodiversity. The payments,

Appendix 1.1 Developing a Governance Model for LSAG

There is a requirement for LSAG to put itself on more robust governance and operational footing. It is required to position the group to adopt a leading role in the consortium in developing Leitrim farmers to ensure their economic, environmental and social futures and the futures of the county's non-farming communities.

LSAG will need to develop a **vision that energises, orients, and engages** its members and the wider Leitrim community. It will be based on an integrated multi-functional model for Leitrim farming. LSAG members will not be inspired if they don't know what they're working toward and don't have explicit goals.

The process LSAG members will involve them agreeing on the following:

- What they will do together to achieve their goals.
- How they will work together - not only what can be written into a new LSAG constitution – but ensuring how all voices are heard, and who is 'in' and who is not

It is essential because:

- Without this written understanding, members can easily find themselves at cross purposes, and the jobs won't get done.
- It will serve as a reference and help to resolve problems in times of controversy.
- Outsiders, especially potential funders, will want to see that your group is democratic and accountable. It involves having a straightforward procedure by which decisions are made.

The adoption of the European Innovation Partnership **Operational Group model** needs to be considered to provide the technical support the group will require to deliver. Operational Groups are intended to bring together stakeholders, including researchers, advisers, businesses, environmental groups, consumer interest groups or other NGOs, to advance innovation in the agricultural and forestry sectors.

The group will require a **management team** supported by the members. The structure of the management team is critical. The aim should be for it to be relatively small and have the required blend of skills. There will be a requirement to provide the management team with some form of reward for good performance in

- Securing the material resources necessary to deliver the group's goals.
- Developing a shared mindset among Group members by fostering a common identity and shared understanding. It may be helpful to have some form of management team evaluation included.

Achieving these outcomes requires facilitated training for both members and the management team.

Appendix 1.2 - The Need for a Consortium Communication Strategy

The fundamental disconnect between Irish urban and farming communities is not new. Despite the COVID-inspired discovery of the open countryside and its value for health and well-being by the mostly urban population, many still believe farmers are responsible for much of Ireland's pollution. It is deeply frustrating for the farmer community to be portrayed in the media in this light as many, if not all, see themselves as custodians of the countryside that they will pass on to the next generation.

This summer's high-profile and often futile media discussion on reduction targets for agricultural greenhouse gas emissions did little to change the perception of the urban farming divide. Little will change in the absence of information packaged modernly.

There is a need to explain and promote and profile farming in the public media. It has been an essentially human enterprise delivering food from the earth's natural capital to feed the population. Farmers have responded and benefited from policy decisions and encouragement to develop their farming systems to meet the needs of the growing world population.

There is little public understanding of farmers' challenges in making a living in an open environment with variable soils and uncontrollable and unpredictable weather. The farming response has increased output using the latest knowledge and technologies to remain viable. However, this intensification has negatively impacted some areas' natural capital, such as water, air, biodiversity and soil. There is a reluctance to pay for the actual cost of food production.

Over the last 30 years in Ireland, terrestrial TV has shifted its services to meet the needs of the larger urban population. It has become increasingly difficult for farmers to communicate amongst themselves and with the broader community. However, today Social Media offers an effective and powerful alternative to control messaging and build better-integrated communities.

Today, more and more farmers use their phones not just for making calls but as a mobile office and banking system. Younger farmers have grown up with Social Media and use it for family, social and business reasons.

Social media channels offer two essential things. It can build

- 1) An engaged farmer community talking amongst themselves, trading ideas, tips, deals, and opportunities and providing support for each other as their day-to-day activities are generally done in isolation.
- 2) Content of interest for the non-farming community would attract them to join with farmers as they manage their area's natural capital or environment.

Social Media can bring communities together and facilitate a range of virtual fora for discussion, demonstrating positives or high points of any week, sharing deals, and opening the possibility of mutually beneficial collaborations. It also allows a communication channel directly to the target audience when an immediate reaction is required or a meeting is called.

Social Media is about **constant communication**. It is not a static thing. One video here and there will not create a community. It needs someone to feed it daily for the first year to get the conversation going. It requires valuable contributions, links, humour, and relevance for the first year while people are cautiously watching and beginning to participate.

When well managed, it will attract interest and members. They will begin using it if it is relevant, and the administration can be reduced. The administration is also needed to ensure detractors or those who might abuse the site can be removed, preserving the space for those interested in growing the community. Eventually, the momentum will build, so it becomes the go-to site to communicate with the local farming community about anything.

Agriculture generally needs to communicate about all the good things it is doing already, the cutting-edge technology being regularly used, and the understanding of soils, weather, crops, animals and the environment. The result will be urban people will begin to understand the challenges and opportunities facing farmers and the benefits they bring to the broader community.

Farmers do not have all the answers, nor do urban people. We are all affected by the quality of the environment in which we live, and we need to understand what that means to preserve and enhance it. Change happens with a shared understanding of what, why and how is required. It will shift the conversation from whining and abuse on both sides to understanding by learning from each other.

Social Media can play an essential role in developing engagement within the project consortium and between the stakeholders with whom they will work to achieve their vision for Letrim farming.

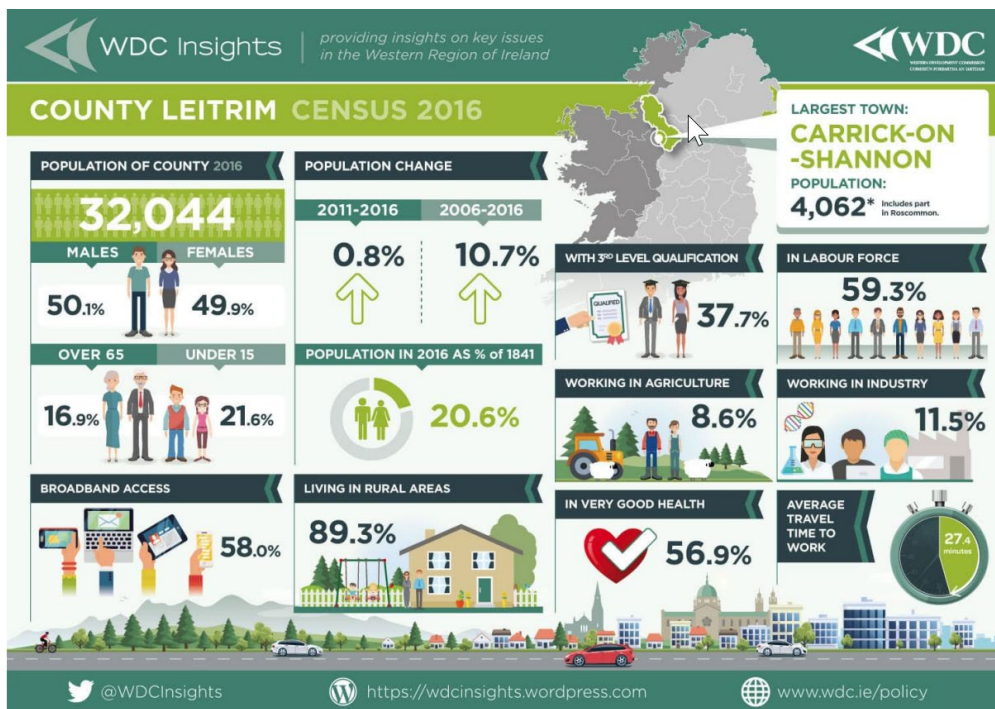
2 INTRODUCTION

This section provides summary details on Leitrim, farming in Leitrim, Forestry in Leitrim and the State of the Irish Environment.

County Leitrim

Leitrim County is situated in the north-west of Ireland. The county's northern half is characterised by mesa (table-like) mountains, lakes and deep glacial valleys. In contrast, the county's southern half is characterised by a drumlin belt interspersed with small lakes and rolling hillocks. Leitrim has several large lakes, including Lough Allen in the centre, Lough Melvin to the northeast of the county and Lough Gill to the west. The total area of the county is 158,885 ha.

The population was recorded at 35,087 people in 2021, the highest since 1961. The slide below presents the results of the 2016 census.



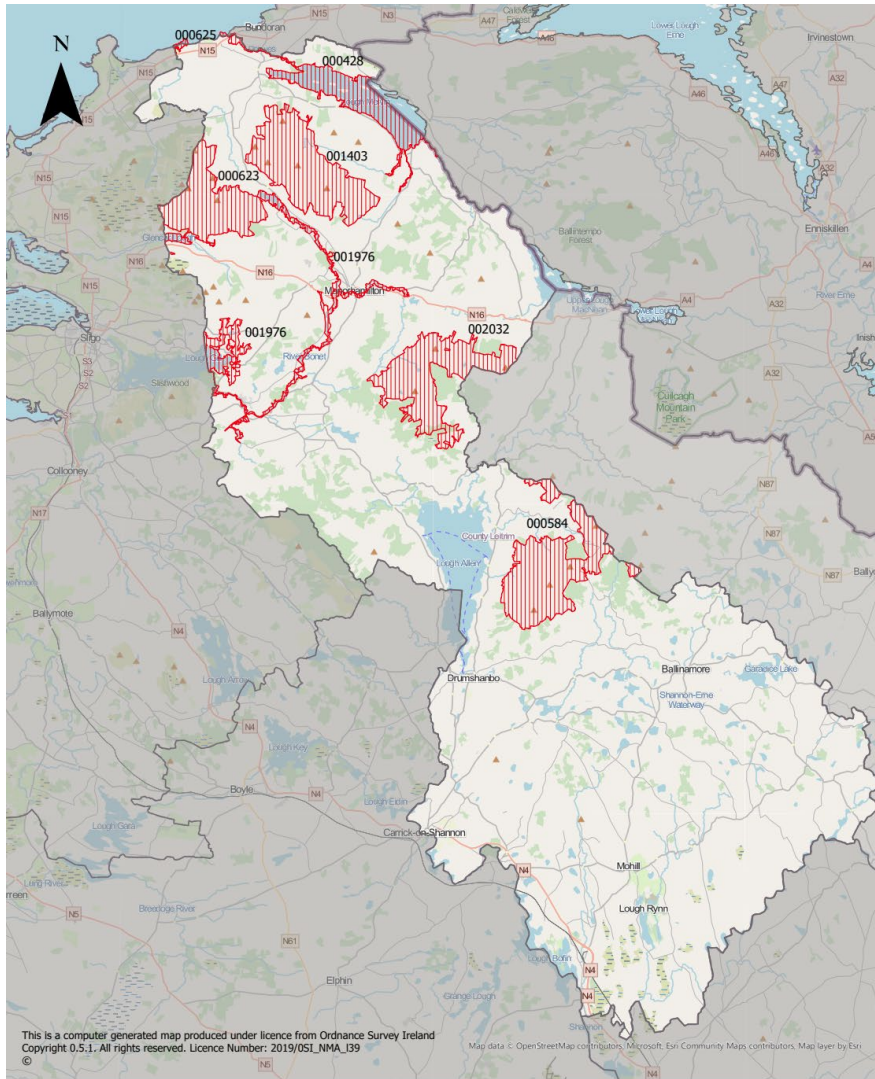
Within the county, 89.3% of the population resides in rural areas and outside of defined urban areas (i.e., towns with over 1,500 people).

Leitrim's agricultural area, primarily grassland and rough grazing, is 104,927 ha or 66% of the country's area. Forestry cover accounted for 18.9% in 2017.

The mean annual precipitation within the county was 1306 mm over the period 2000-2018.

Under the Birds and Habitats Directives, introduced in 1979 and 1992, respectively, areas have been designated to protect threatened, rare and vulnerable species and habitats across Europe and to ensure their survival, including Special Protection Areas for Birds (SPAs) and Special Areas of Conservation (SACs). Collectively, SPAs and SACs form the Natura 2000 network of protected areas.


There are eight SACs and nine NHAs in Co. Leitrim



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List of Special Areas of Conservation

Ref No.	Name of Area	Ref No.	Name of Area
000428	Lough Melvin	001919	Glenade Lough
000584	Cuilcagh-Anierin Uplands	001403	Aroo Mountain
000623	Benbulbin, Gleniff and Glenade Complex	001976	Lough Gill
000625	Bunduff Lough and Machair/Trawalua/Mullaghmore	002032	Boleybrack Mountain

Map No. 5	Produced by Planning Department, Leitrim County Council, Áras an Chontae, Carrick-on-Shannon, Co. Leitrim
Special Areas of Conservation	
Leitrim Draft County	

There is also one SPA (which straddles the Sligo/Leitrim border) for two birds, the Peregrine (left photo and the chough (right photo).



List of Special Protection Areas

Ref No.	Name of Area
004187	Sligo/Leitrim Uplands

Map No. 6

Special Protection Area

Leitrim Draft County Development Plan

Produced by Planning Department, Leitrim County Council, Áras an Chontae, Carrick-on-Shannon, Co. Leitrim



Almost all the NHAs are blanket bogs.



List of Proposed Natural Heritage Areas

Ref No.	Name of Area	Ref No.	Name of Area	Ref No.	Name of Area
000424	Cloonee Wood And Lough	001412	Drumhierry Wood	001920	Carrickaport Lough
000426	Kilgarriff Marsh	001413	Garadice Lough Wood	001976	Lough Gill
000427	Lough Allen, South End and Parts	001415	Kinlough Wood	001919	Glenade Lough
000428	Lough Melvin	001417	Lough Rinn		
000584	Cuilcagh - Anierin Uplands	001418	O'Donnell's Rock Wood		
000623	Ben Bulbin, Gleniff And Glenade Complex	001419	Owengar Wood		
000625	Bunduff Lough And Machair/Trawalia/Mullaghmore	001421	Sheemore Wood		
000983	Glasshouse Lake	001542	Lough Bodeg And Lough Bofin		
001402	Annagheary Lough	001643	Lough Drumharlow		
001403	Arroo Mountain	001807	Lough Errew		
001407	Corduff Lough	001808	Lough Sallagh		
001409	Cromlin Bridge Wood	002032	Boleybrack Mountain		

Map No. 8

Natural Heritage Designations

Produced by Planning Department, Leitrim County Council, Áras an Chontae, Carrick-on-Shannon, Co. Leitrim

Leitrim Draft County Development Plan 2023-2029



Farming in Leitrim

The first people inhabiting Ireland, around 7000 BC, were hunters' gatherers and were part of the Stone Age. The lifestyle was to move from location to location in search of food growing wild such as fruits, nuts and berries. Their diet would have been supplemented by hunting for whatever animals and birds they could catch. They never stayed in one place and would have spread out across Ireland. They lived undisturbed like this for more than 3,000 years.

The arrival of a new wave of settlers around 4000 BC – the start of the Neolithic Period (4000 to 2000 BC) and a warming climate saw the introduction of the cultivation of crops and domestication of animals. These practices originated in the Middle East about 12,000 years ago.

Farming began in Ireland with the domestication of goats, sheep, cattle, and pigs and cultivated a primitive form of wheat and barley. The hunter-gatherer population adopted it over time because it provided a more reliable food source for them and their families. Ecosystem services were focused on providing food, fuel, and shelter. Over the millennia that followed, farmers cleared dense oak and elm forests to plant crops and enable their animals to graze as the population increased. Creating a year-round food supply allowed people to live in permanent settlements. Forests were cleared, and farmed areas increased in response to the increasing population. The Great Famine resulted in the death or migration of over 2 million people reducing the population by 25%. There are some records of Leitrim agriculture available² from pre-famine times.

In the late 1800s, Horace Plunkett drove the establishment of a devolved Department of Agriculture³. In the poor, post-famine period, when the land was being transferred from the landlords to Irish farmers, he identified the need for a support and development service. Education was the focus. The local farm advisory service was established in 1898, resulting in the incremental improvement of production over the generations. Interestingly, there was female advisory support for farming women with an essential focus on poultry production to supplement the farm income.

By the 1950s, there was a specialisation happening in Irish agriculture, and the advisory service needed research support to provide the knowledge farmers required. In 1958, An Foras Taluntais was established to meet this need. The transformation of Irish farming focused on food production received its final push following the country's accession to the EU.

In Ireland, agri-food is an integral part of the economy and society⁴. In 2020, the sector accounted for over 6% of GNI and 9% of exports in value terms. The sector accounts for 38% of total indigenous exports and over 60% of indigenous manufactured exports. The sector employed 163,600 people or 7.1% of total employment in 2020. Some 137,500 farms producing over €8.2 billion in output.

The intensification of farming across the country was not the same for all counties. In the south and east of the country, with freer draining soils, better grass production conditions, larger farms (43 ha) and younger (54 years) farmers focused on dairy and tillage and developed more intensive high-output

² [Leitrim Agriculture - Topographical Dictionary of Ireland \(1837\) \(libraryireland.com\)](https://www.libraryireland.com/Leitrim-Agriculture-Topographical-Dictionary-of-Ireland-1837/)

³ <https://www.irishtimes.com/culture/books/how-did-irish-agriculture-come-so-far-so-quickly-1.4755945>

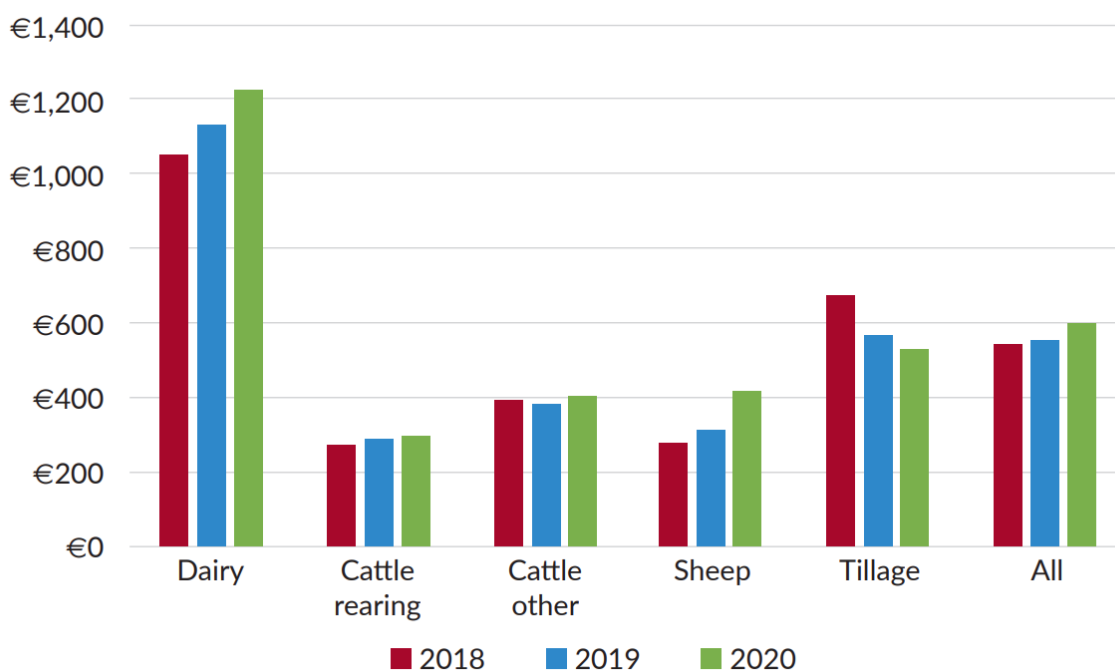
⁴ <https://assets.gov.ie/205578/26036bdf-d590-43b2-a361-327dd9ea2afb.pdf>

systems. Seven in ten of all dairy farms are in the southern region. Most tillage farms are in the southern region (55.0%) and the Eastern and Midland region (40.6%)⁵.

The leading farm enterprises in the Border and West Regions, including Leitrim, are beef and sheep systems. Almost two-thirds of Irish sheep and half of Irish beef farmers are in the region. The 57,500 older farmers (59 years) manage more difficult poor draining soils, sometimes at a higher elevation, on smaller farms (26 ha), with a wetter cooler climate could not intensify to the same extent as their neighbours in the south and east.

Interestingly, dairy and tillage farms have increased by approximately 10 ha between 2010 and 2020, while it remained unchanged for specialist beef and sheep farms.

The 2020 Teagasc National Farm Survey showed that Family Farm Income (FFI - the return from farming for farm family labour, land and capital) found significantly higher FFIs on dairy farms than on any other farm type. Dairy farms again produce higher FFI per hectare when distinguishing between full-time and part-time farms in terms of labour input.



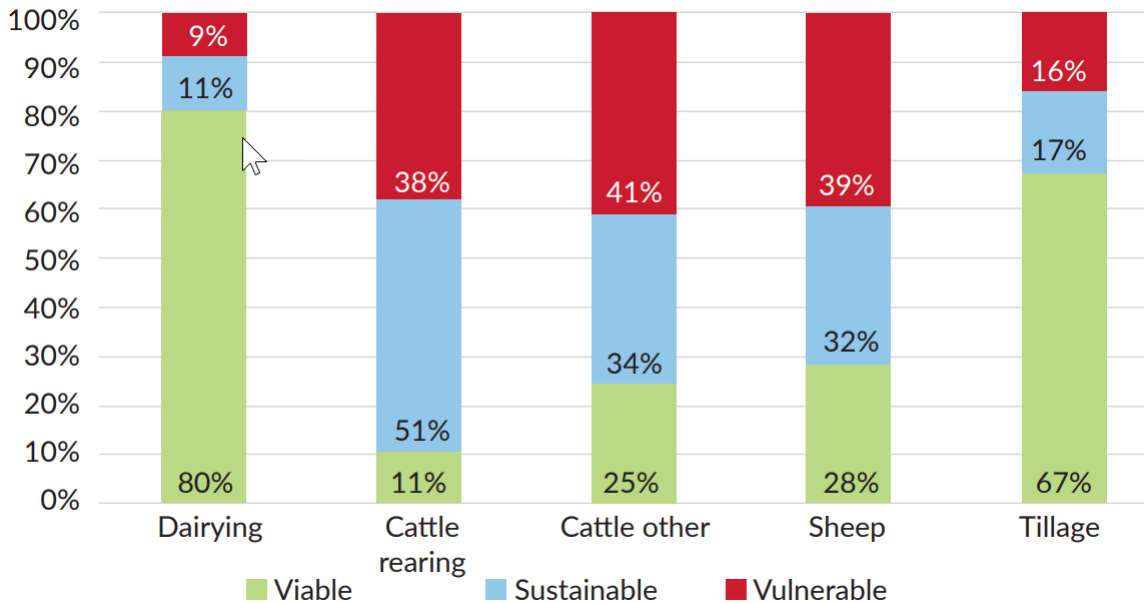
Cattle-rearing farms, at €294 per hectare, up from €288 in 2019, had the lowest return per hectare. Sheep FFI was €417 per hectare in 2020. Sheep farms have an average size of 44 hectares, down from 47 hectares in 2019.

Subsidies and Direct Payments contribute to FFI on all farms. They are significant on part-time farms, where they make up 126% of the FFI. Without these payments, the farm would be making a financial loss. While they are also important on full-time farms, they contribute far less proportionately to the

⁵ <https://www.cso.ie/en/releasesandpublications/ep/p-coa/censusofagriculture2020-preliminaryresults/kf/>

average FFI at 47%. In 2020, the 3,507 farmers in Leitrim received €22.48 million in subsidies and direct payments.

The National Farm Survey estimates the viability of the main farming systems. Viable farms are those where family farm income can provide a return on labour and capital; Sustainable is where the farmer or spouse has an off-farm income; Vulnerable is where the farm is not viable, and there is no off-farm income. The 2020 results show that almost 40% of cattle and sheep farmers are vulnerable.



Forestry in Leitrim

A recent report⁶ on forestry in Leitrim found forest cover in 2017 was 18.9%. It is the highest percentage of forest cover among all counties and is substantially higher than the national level of 11.0%. Sitka spruce is the dominant species in the forests in the county, accounting for 61.3% of the total forest area. Native species account for 30.7% of the forest area in the county.

A survey⁴ found

- Just over two-thirds of owners of forests in Leitrim had planted forests on their land.
- Twenty-six per cent (26%) were investors (*i.e.* they bought land/forest purposely for investment).
- Five per cent had inherited their forest.
- About 30% of the forest owners were not residents of Leitrim (half of these were from neighbouring counties).
- The average size of an individual forest plot was 6.92 ha. Forty per cent had planted more than one plot. The average total area planted per owner was 14.0 hectares.

⁶ https://www.leitrimppn.ie/wp-content/uploads/2019/09/The-Socio-Economic-Impact-of-Forestry-in-Co.-Leitrim-Final-Report_compressed.pdf

- Seventy-five per cent of owners were farmers (full-time, part-time and retired).

Forestry was responsible for 14% of the risk to waterbodies in the county. In 2017, there were 309 jobs created by forestry with a direct economic value of €15 m. The total carbon stock of Leitrim's forests was estimated at 12.6 m tonnes.

An earlier study of forestry and land use in Co. Leitrim, the Leitrim Resource study⁷ conducted in the 1970s, identified the potential of the land in the county for forestry. It also identified extreme resistance amongst farmers in the county to selling land for afforestation. At the time, afforestation was almost exclusively carried out by the State. Today, there remains a substantial divergence of opinion in the community about forestry as a land use, its role in the community and national forestry policy. For example, the Save Leitrim website⁸ reports:

“The plantation of the Sitka spruce has been going on for 40 years or more. Over 50% of the available lands are covered in industrial conifer plantations. That’s over 20% of the total area of County Leitrim. Several areas across rural Ireland, including Co. Leitrim, are suffering from the government’s policy, which severely impacts people, their lives, mental health, businesses, communities, biodiversity, wildlife and their rights. It is now exacerbating the decline in these communities and rural areas. One hundred forty-seven townlands in Leitrim are now abandoned, with many fully planted in conifers.”

and

“Farmers and farms are displaced, and their numbers are reduced as farm after farm is sold or planted. It has a downstream knock-on decline in businesses supporting and servicing farmers (agri-suppliers, vets, marts, contractors, machinery mechanics, etc.) and in the towns and villages in these areas. Farmers cannot expand or develop their holdings due to the hike in the price of land by the tax breaks and grants for forestry and being snapped up by outside investors getting very significant profit or return on their investments”.

The State of the Irish Environment

The intensification of Irish farming over the last 50 years has negatively impacted the environmental media. The media include water quality, biodiversity, air quality (ammonia and greenhouse gas (GHG) emissions) and soil health. While farming is not alone in this respect, the consequences are a reduced quality of the environment in which we live and work.

The 2020 EPA State of the Environment report⁹ provides information about the quality of Ireland's environment. It focuses on the actions required to protect the environment that is under increasing threat. It highlights the need for vision and implementing policies and measures necessary to deliver an environment compatible with our health and well-being. The report notes the need for systematic changes to achieve a climate-neutral and resilient society.

- **Climate:** More urgency is needed to deliver climate mitigation and adaptation actions and ensure that Ireland meets its international obligations to reduce greenhouse gas (GHG)

⁷ <https://www.teagasc.ie/media/website/environment/soil/Leitrim-report-1.pdf>

⁸ <https://saveleitrim.ie/business/>

⁹ <https://www.epa.ie/our-services/monitoring--assessment/assessment/irelands-environment/state-of-environment-report/>

emissions. Ireland's GHG emissions, with full implementation of the Climate Action Plan, are projected to decrease annually by 3 % between 2021 and 2030. However, further measures are required to meet national and EU ambitions to keep the global temperature increase to below 1.5°C.

- **Nature:** The EPA report notes that nature and wild places are at risk in Ireland and must be better safeguarded locally and in protected areas. The next Biodiversity Action Plan needs to be more ambitious and identify the pathway to transformative change for nature protection in Ireland. It needs to develop and further strengthen the security of our national network of protected areas for future generations and to reverse trends in biodiversity and habitat loss.
- **Water Quality:** Water quality in Ireland's rivers, lakes and estuaries needs to be better protected through evidence-based measures, integrated water catchment-based projects and initiatives and by reducing the quantity of nutrients ending up in water courses.
- **Environmentally Sustainable Agriculture:** An agricultural and food sector demonstrating validated performance around producing food with a low environmental footprint. More holistic farm management and water catchment-level management approach, encompassing all environmental pressures, will be fundamental to progress towards a more environmentally-sustainable and carbon-neutral food production system.
- **Land Use:** The development of an integrated national approach to land mapping could support better land use and management practices decision-making. It could contribute significantly to mapping land use change and managing competing environmental pressures, such as agriculture, urbanisation, tourism and recreation, energy projects, carbon sinks, ecosystem services and space for nature.

The report notes that "the protection of our waters, air, soil, ecosystems and biodiversity should not just be an ambition driven by altruism, as these systems and species provide essential supporting services for our wellbeing and economy". The delivery of trusted and actionable knowledge about our environment is essential to allow Ireland to plan with any degree of certainty for a better future

Ireland is not alone in this respect, nor is agriculture the only activity impacting our natural capital. It is worldwide and recognised by the United Nations when it established The Millennium Ecosystem Assessment¹⁰. The report provided an assessment of the consequences of ecosystem changes on human well-being and found that:

- Our growing demand for food, fresh water, timber, fibre, and fuel has resulted in a substantial and largely irreversible loss in the diversity of life on Earth.
- Changes to ecosystems which contributed to human progress and economic development were achieved at the expense of our ecosystem.
- There are some partial solutions to the current environmental crisis. However, action by national governments remains limited and slow-paced.

¹⁰ <https://www.millenniumassessment.org/en/Index-2.html>

3. POLICY CONTEXT

In the early 1970s, the challenges of farming in Leitrim were identified as follows:

- **Heavy, poorly drained soils** and a relatively **wet climate**. Predominantly grassland farming system encounters serious problems such as **poaching by grazing animals, short grazing season**, the necessity for conserving large amounts of winter fodder, and **poor trafficability for farm machinery**. This latter problem is accentuated by many steep slopes associated with the predominant drumlin topography.
- **Farm size is small**, a population structure dominated by the old and very young.

Positive agriculture and rural development progress required an inventory of the County's resources that would allow recommendations to be made on alternative land use systems to improve the welfare of the people of Leitrim.

An Foras Taluntais (now Teagasc) undertook a significant study

- To provide information on Leitrim's physical, economic and sociological resources against the principal rural problems of low farm income could be analysed.
- To assess the optimum land-use enterprises for Co. Leitrim, bearing in mind the predominant soils and climate.
- To assess the potential for development within the County of a stable population where farm incomes would reach at least a minimum acceptable viable level.
- Assess the potential for tourist income development

In 1973 it published a series of reports¹¹.



¹¹ <https://www.teagasc.ie/crops/soil--soil-fertility/county-soil-maps/>

It is interesting that almost 50 years later, the Leitrim CoCo LSAG consortium is re-assessing the challenges of Leitrim farming. There has been no change in the County's soil's resources. However, a new range of opportunities is evolving from the expanding knowledge of Leitrim's outstanding natural and cultural capital. The interest, in part, has been driven by EU, National and Local policies.

The European **Green Deal**¹² aims to transform the EU into a modern, resource-efficient and competitive economy, ensuring:

- No net emissions of greenhouse gases by 2050
- Economic growth decoupled from resource use
- No person and no place is left behind

The Green Deal aims to improve the wellbeing and health of European citizens and future generations.

 <p>fresh air, clean water, healthy soil and biodiversity</p>	 <p>renovated, energy efficient buildings</p>	 <p>healthy and affordable food</p>	 <p>more public transport</p>
 <p>cleaner energy and cutting-edge clean technological innovation</p>	 <p>longer lasting products that can be repaired, recycled and re-used</p>	 <p>future-proof jobs and skills training for the transition</p>	 <p>globally competitive and resilient industry</p>

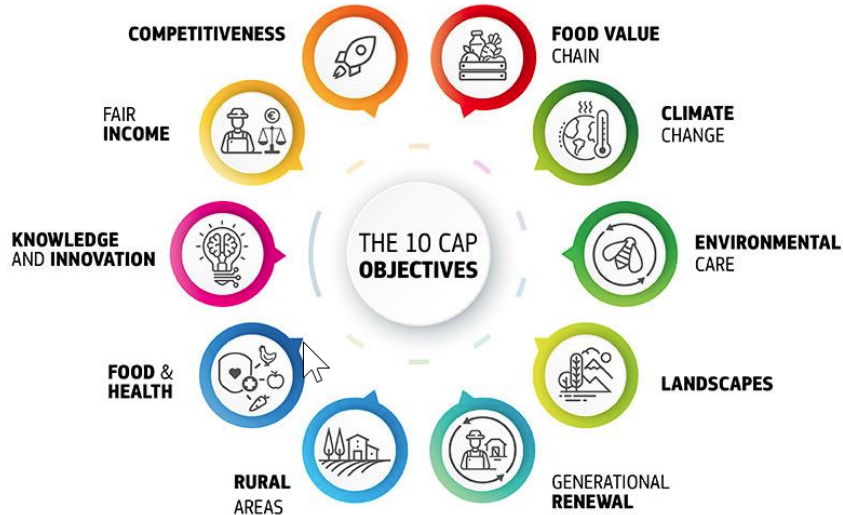


“Making nature healthy again is key to our physical and mental wellbeing and is an ally in the fight against climate change and disease outbreaks. It is at the heart of our growth strategy, the European Green Deal, and is part of a European recovery that gives more back to the planet than it takes away.”

Ursula von der Leyen, President of the European Commission

¹² https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

The new **CAP 2023-27 policy**¹³ is key to securing the objectives of the Green Deal. It has ten key goals¹⁴ that are shown in the figure below.



These are linked to the EU goals for agriculture and rural areas, *i.e.*, social, environmental and economic sustainability. The new CAP has a strong emphasis on results and performance. It includes reforms in the areas of a greener, fairer CAP that will strengthen the position of farmers in the supply chain.

The new CAP is also a tool to assist in implementing the ambitious Biodiversity and Farm to Fork strategies.

The **EU's Biodiversity Strategy**¹⁵ for 2030 is a comprehensive, ambitious and long-term plan to protect nature and reverse the degradation of ecosystems. The strategy aims to put Europe's biodiversity on a path to recovery by 2030 and contains specific actions and commitments. The actions include

- Establishing a more extensive EU-wide network of protected land and sea areas.
- Putting in place effective measures to restore degraded ecosystems
- Introducing measures, including funding, to ensure enhanced implementation of environmental policies, tracking progress, improving knowledge, sustainable financing & investment and better consideration of nature in public and business decision-making.
- Increased usage of online tools to track progress in implementing the strategy.

¹³ https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/new-cap-2023-27_en

¹⁴ https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/new-cap-2023-27/key-policy-objectives-new-cap_en

¹⁵ https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

The Farm to Fork strategy¹⁶ aims to make systems fairer, healthy, and environmentally friendly.



The EU Farm to Fork Strategy aims to accelerate our transition to a sustainable food system that should:

- Have a neutral or positive environmental impact.
- Help to mitigate climate change and adapt to its impacts.
- Reverse the loss of biodiversity.
- Ensure food security, nutrition, and public health, and everyone can access sufficient, safe, nutritious, sustainable food.
- Preserve food affordability whilst generating fair economic returns for farmers, fostering the competitiveness of the EU supply sector and promoting fair trade.

In 2021 the Irish government launched its **Food Vision 2030 Strategy** - a new ten-year Strategy for the Irish agri-food sector.

¹⁶ https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

- A vision is that Ireland will become a world leader in Sustainable Food Systems over the next decade.
- Delivering significant benefits for the Irish **agri-food sector**, Irish **society** and the **environment**.
- Provide a basis for the **economic, environmental and social future** of the sector .
- Ireland will seek to become a global leader of innovation for sustainable food and agriculture systems, **producing safe, high-value food while protecting and enhancing our natural and cultural resources** and contributing to **vibrant rural and coastal communities** and the **national economy**.
- The Strategy has four high-level missions for the sector to work toward:
 - A Climate Smart, Environmentally Sustainable Agri-Food Sector.
 - Viable and Resilient Primary Producers with Enhanced Wellbeing.
 - Food Which is Safe, Nutritious And Appealing, Trusted And Valued at Home and Abroad.
 - An Innovative, Competitive and Resilient Agri-Food Sector, Driven by Technology And Talent

The **Leitrim Development Plan 2023-2029** (Draft) presents a strategy for the County's sustainable development. The Plan is built around the County's sustainable physical and social development, conserving the natural and built environments. It seeks:

- To ensure that wildlife species and habitats are conserved, features of heritage interest are protected, watercourses and groundwater are safeguarded from pollution, and the beauty of the landscape is maintained.
- To grow sustainable tourism, diversify rural enterprise and encourage remote working hubs throughout the County, all facilitated by the rollout of broadband infrastructure.
- To attract those wishing to work from home to our rural lifestyle, unspoilt landscape, and many outdoor recreation facilities.
- To reduce greenhouse gas emissions and capitalise on projects that allow us to become a low carbon, climate resilient and environmentally sustainable economy.

Leitrim Development Plan 2023-2029
Vision

*Co. Leitrim to be a vibrant, creative, economically strong, socially inclusive, progressive and distinctive county, providing a quality experience for all who live in, work in, invest in and visit our county, **fostering the development and wellbeing of our communities**, offering excellent opportunities for employment across a diverse range of sectors, **embracing the challenges which climate change presents in a responsible and practical manner while protecting, conserving and enhancing the best of the natural and built environment**".*

The 2023-2029 Development Plan also outlines a vision for Rural Development.

**“Leitrim Development Plan 2023-2029
Rural Development Vision**
*“To support **agriculture and the rural economy whilst protecting the environment** and maintaining a stable population in rural areas to ensure the maintenance of vibrant rural communities”.*

The objective is **to facilitate the development of agriculture while ensuring that natural waters, wildlife habitats and conservation areas are protected from pollution.** To achieve this objective, it outlines the following policies:

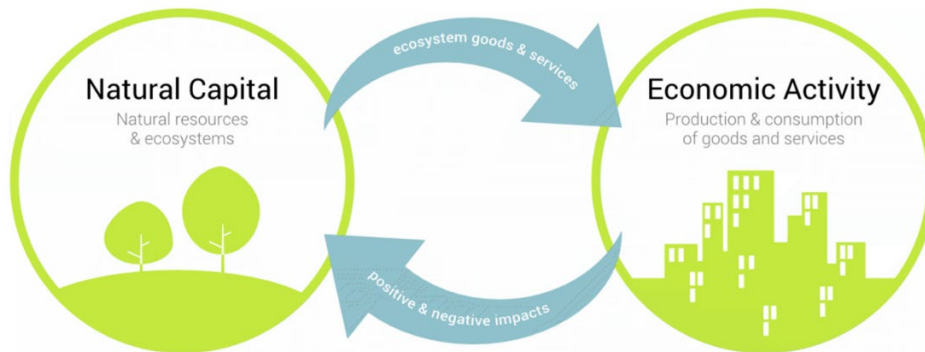
- To maintain a vibrant and healthy agricultural sector based on the principles of sustainable development whilst at the same time finding alternative employment in or close to rural areas to sustain rural communities.
- To support and facilitate farm diversification, including
 - Added-value food.
 - Renewable energy.
 - Organic food.
 - Agritourism enterprises - visitor accommodation, open farms and health farms.
- To work with **relevant stakeholders in identifying and protecting from inappropriate forms of development areas of High Nature Value agricultural land** in the County to include consideration of future climate scenarios and water quality and availability for agricultural purposes.
- To support and encourage **farm-based renewable energy technologies** to improve the shift toward a low-carbon and climate-resilient economy in the agriculture, food and forestry sectors.
- To support and encourage the **participation and development of careers in agriculture for our young people** and support the progression of land leasing and farm partnership schemes.

The Plan, therefore, **supports the development of agriculture through diversification, including tourism and recreational activities to enhance wellbeing while protecting the natural and cultural capital.**

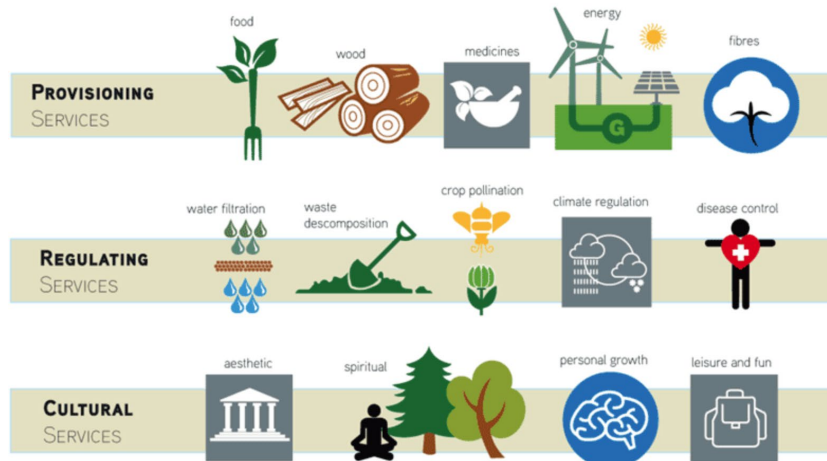
There is a significant alignment in the County's Development Plan 2023 – 2029 with the EU policies and strategies. The alignment indicates that Leitrim Farming has never had a better opportunity to explore how it can take advantage of EU and local rural development policies, environmental policies, strategies and funding opportunities. Capitalising on them will ensure the economic, environmental and social future for farmers and the broader community.

4. NATURAL CAPITAL¹⁷

The emphasis on EU growth policies and strategies, expressed in the Leitrim Development Plan, has evolved to focus on natural capital. Natural capital is the world's stock of natural assets, including geology, soil, air, water and all living things. From this natural capital, humans derive a wide range of services, often called ecosystem services, which make human life possible. Natural capital and economic activity are linked¹⁸. It is used to deliver a wide range of ecosystem services. However, providing them can positively or negatively impact the natural resources or ecosystems.



There is a range of ecosystem services summarised in the diagram below¹⁹. They are divided into three types Provisioning, Regulating and Cultural.



¹⁷ <https://www.naturalcapitalireland.com/>

¹⁸ <https://www.naturallogic.org/>

¹⁹ https://www.euskadi.eus/contenidos/informacion/servicios_ecosistemas/en_def/#tab_item913

The world climate this summer (2022), characterised by heatwaves²⁰ and catastrophic flooding²¹, highlights one of the significant risks if we continue to use this capital to deliver ecosystem services without giving nature a chance to recover. These economic and social risks arise from hunger, biodiversity loss, reduced water, air and soil quality, and climate change.

However, in Leitrim, our outstanding stock of natural capital remains high, though not without risk. The challenge is how we best manage it to deliver the vision the County has for itself.

²⁰ <https://www.ecmwf.int/en/about/media-centre/focus/2022/european-heatwave-update-drought-and-extended-range-forecasts>

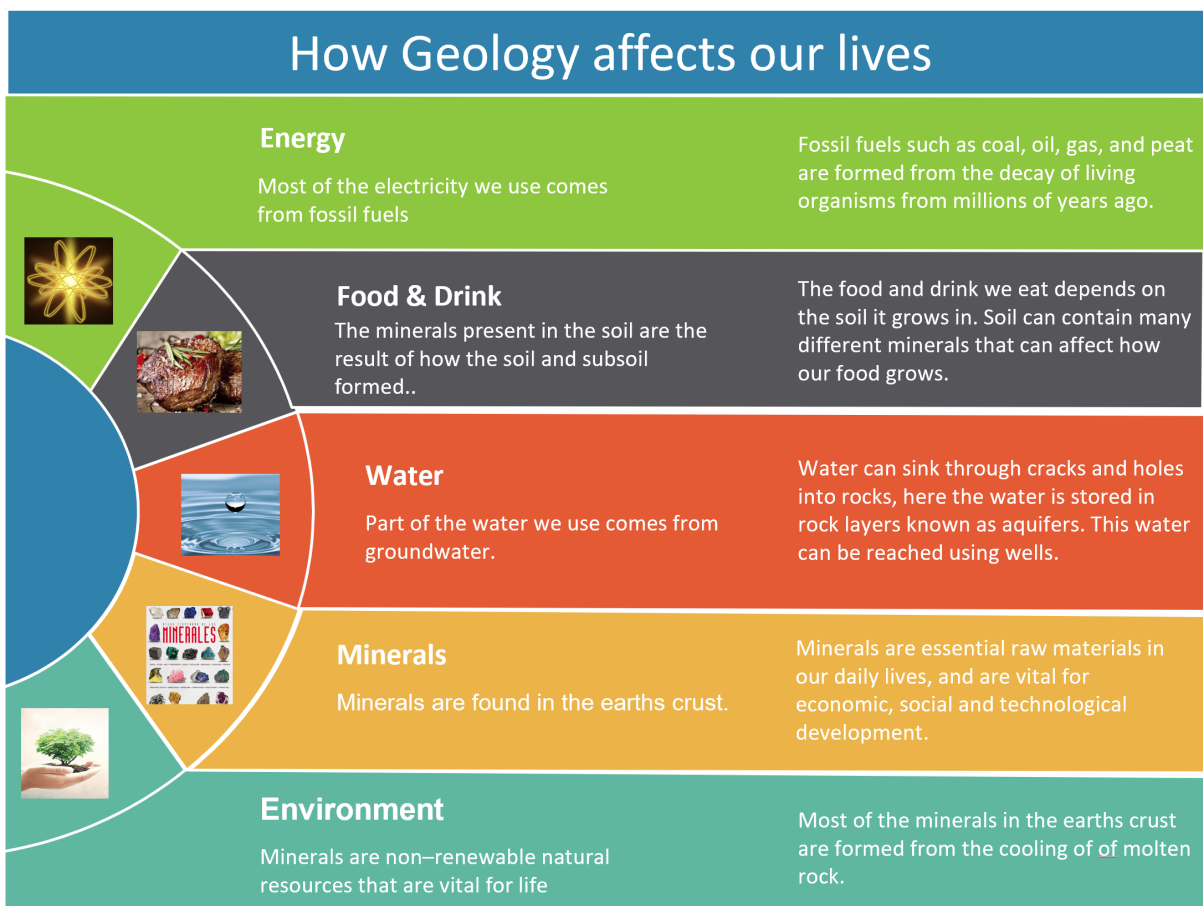
²¹ <https://www.unicef.org/emergencies/devastating-floods-pakistan-2022>

5. GEOLOGY

The objective of this section is to highlight the role of geology as part of Leitrim’s natural capital. It is the part of nature that is not alive – minerals, fossils, soils, mountains – and the geological processes that have shaped the county’s landscape. It is the silent partner to biodiversity, helping to understand the complex connections between the living and non-living worlds.

Geodiversity underpins food production, water management and energy production. It is also central to the 'green' transition: when used wisely, mineral resources can create wealth and jobs while decarbonising development, all prerequisites for a sustainable future.

The word Geology means 'Study of the Earth'. Also known as Geoscience or Earth Science, Geology is the primary Earth science and looks at how the Earth formed its structure and composition and the types of processes acting on it. It is concerned with the Earth's history throughout its 4.5-billion-year life. By studying the planet's structures, we can unlock its hidden past and anticipate its future²².



Geodiversity is the part of nature that is not alive – minerals, fossils, soils, mountains – and the geological processes that shape our landscape. It is the silent partner to biodiversity, helping us to understand the complex connections between the living and non-living worlds.

²² <https://www.gsi.ie/en-ie/education/what-is-geology/Pages/Why-do-we-study-geology.aspx>

Geodiversity underpins food production, water management and energy production. It is also central to the 'green' transition: when used wisely, mineral resources can create wealth and jobs while decarbonising development, all prerequisites for a sustainable future.

Understanding geological processes are essential to explore the past, enjoying the present and preparing for an unpredictable future.

The Geology of Leitrim²³

The differences in Leitrim's landscape and biodiversity are evident, travelling from south to north. There is no "one size fits all" land management system for delivering ecosystem services.

Bespoke management systems, reflecting the capacity of the soils, landscape, and land managers, primarily farmers, are required to provide the most sustainable mix of ecosystem services. These include food, habitats, water and flood control, carbon sequestration, recreation and energy generation.

Sustainable landscape management has never been more vital for Leitrim's future. Appreciating and understanding Leitrim's geology and its evolution (geomorphology) can help deliver the types of management required to secure a financial, environmental, and social future for its farmers and people.

Geology is important because it provides the platform on which all life is formed. Life began when water was added to the rocks about 4.4 billion years ago. The new lifeforms have evolved and adapted to the changing landscape and climate from microorganisms to form a biological species-rich Irish biodiverse ecosystem that awaited the arrival of the first human habitation about 10,000 years ago. The influence of human activity on our ecosystems, what we call our cultural heritage, is inseparable from the natural heritage of the landscape.

Leitrim's Geological Record.

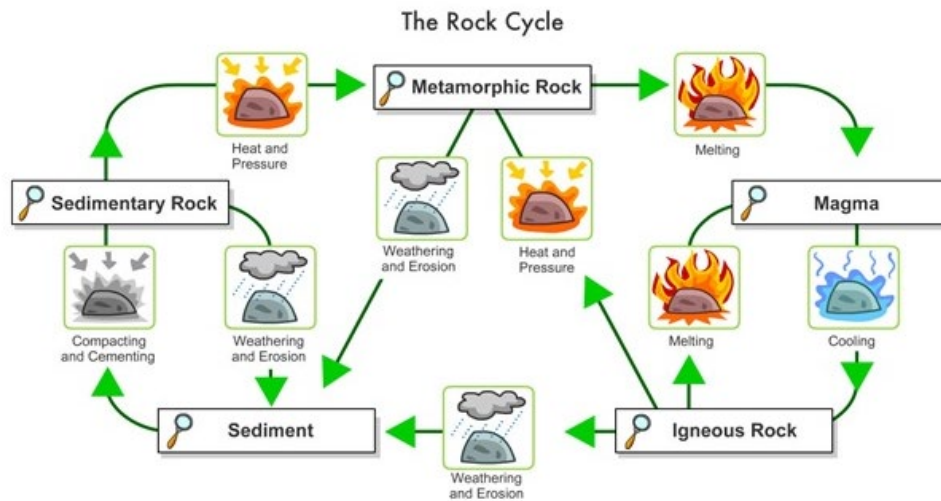
Leitrim's scenic landscapes have formed over hundreds of millions of years by various geological processes, each leaving its mark in the rock record. This turbulent and varied geological history profoundly affects the land use tapestry displayed atop the land surface. Careful examination of the rocks in the region can help unravel the mysteries surrounding their formation and thus shed light on



²³ Robbie Meehan & Owen Carton

the evolution of Leitrim's terrain and land use patterns, the foundation on which the County's natural and cultural heritage has and continues to evolve.

The diagram below shows that rocks can be divided into three main groups: sedimentary, igneous and metamorphic. All three groups are exposed in Leitrim.



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Igneous rocks crystallise from magma (molten or semi molten materials) originating deep beneath the Earth's surface and may be extrusive (*i.e.* lava flows at the Earth's surface) or intrusive (emplaced within the Earth's crust, below the surface) *e.g.*, granite

Sedimentary rocks are laid down in rivers, lakes or seas as particles of material such as sand or mud and then hardened by compaction and lithification into sandstones, siltstones, mudstones and limestones. Fossils, often preserved in these rocks, can give us an idea of when the rock formed and what the climate and environment were like at that time. For, example, limestone or sandstone.

Metamorphic rocks are sedimentary or igneous rocks that have been altered by changes in temperature and/or pressure. New minerals grow in response to these changes and their composition depends on the composition of the original rock, and the temperatures and pressures that affect it. For example, marble.

There is usually more than one rock type (or lithology) in any locality. The various rock units are generally interlayered as you move down from the ground surface. Ranges of rock lithologies over a small area are essentially congruous. These rock sequences often share common characteristics allowing them to be grouped as packages or geological units. The most important of these 'units' is the formation, a sequence of related rock types differing significantly from adjacent sequences.

Leitrim's rock formation or geology story is fascinating and immensely important. It is interesting as it has evolved over 1.8 billion years – see Table below. If the timescale was a 24-hour clock, Earth's planet was started one second after midnight. Ireland's oldest rocks, deposited around 1.7 billion

²⁴ <https://www.gsi.ie/en-ie/education/rocks-minerals-and-gems/Pages/The-rock-cycle.aspx#:~:text=These%20different%20rock%20types%20can,metamorphic%20or%20another%20igneous%20rock.>

years ago (11.00 AM on the 24-hour clock), are found in northwest Ireland. Between then and the start of the Ice Ages, 2.5 million years ago or (11.59.38 pm, on the 24-hour clock, *i.e.*, just before midnight!), there were a series of periods during which rocks were formed. Each of these periods has been given a name. For example, the Cambrian period occurred between 541 and 485 million years ago, or an interval of 56 million years.

Geological Timescale and County Leitrim.

AGE (Million Years Ago)	ERA	PERIOD	EVENTS IN LEITRIM (non-italics)	IF THIS TIMESCALE WAS A DAY LONG...
2.58	Cenozoic	Quaternary	Several Ice Ages smothered Leitrim, followed in the last 10,000 years by the spread of vegetation, growth of bogs and arrival of humans. Deep glacial valleys sculpted at Glencar and Glenade. Deposition of (till) boulder clay in ribbed moraines, drumlins and moulding of crag-and-tails. Dissolution of limestone beneath Quaternary sediments.	Ice ages would begin 38 seconds before midnight
23		Neogene	Erosion, mainly limestone. Caves, swallow holes, cavities, and underground streams develop in the North and Central Leitrim uplands.	The Neogene period begins at 11.52 PM
66		Palaeogene	The intrusion of volcanic dykes near Lough Melvin, Lough Macnean and Manorhamilton.	The Palaeogene period begins at 11.40 PM
145	Mesozoic	<i>Cretaceous</i>	<i>Erosion. No record of rocks of this age in Leitrim.</i>	11.15 PM
201		<i>Jurassic</i>	<i>Uplift and erosion. No record of rocks of this age in Leitrim.</i>	Age of the dinosaurs, starting at 10.55 PM
252		<i>Triassic</i>	<i>Desert conditions on land.</i>	10.42 PM
299	Palaeozoic	<i>Permian</i>	<i>No record of rocks of this age in Leitrim.</i>	10.30 PM

359		Carboniferous	<p>The land became submerged, limestones with some shales and sandstones deposited around much of County Leitrim in tropical seas.</p> <p>The majority of limestones remaining today are pure and unbedded, with smaller areas of muddier limestones at the edges.</p> <p>Shales and sandstones were deposited in the Bencroy district with some coal seams.</p>	<p>Inundation of land by sea around 10.10 PM</p>	
419			Devonian	<p>Caledonian mountain building.</p> <p>Sandstones were deposited south of Drumshanbo.</p>	'Old Red' Sandstone deposited at 9.52 PM
443			Silurian	<p><i>Shallow seas following the closure of Iapetus Ocean.</i></p> <p><i>No record of rocks of this age in Leitrim.</i></p>	Starts at 9.42 PM
485			Ordovician	<p>Iapetus Ocean divides Ireland into two.</p> <p>Greywackes, shales, argillites and volcanic rocks form around and Southeast of Carrigallen and Southwest of Mohill.</p>	Begins at 9.28 PM
541			Cambrian	<p><i>Opening of the Iapetus Ocean.</i></p> <p><i>No record of rocks of this age in Leitrim.</i></p>	Starts at 9.11 PM
2500			Proterozoic	<p>Some of Ireland's oldest rocks are deposited in northwest Ireland.</p> <p>Quartzites, gneisses and schists of this age are present in a wide, crescentic band between Dromahair and Manorhamilton.</p>	Beginning 11.00 am
4000	Archaean	Precambrian	<i>Oldest known rocks on Earth.</i>	Beginning 3.00 AM	
4600			<i>Age of the Earth.</i>	Beginning 1 second after midnight	

The Precambrian to the Devonian Period (4.4 billion to 419 million years ago).

Sliswood Division: Precambrian rocks are some of the earliest ones formed and still found on Earth. The oldest Precambrian rocks in Leitrim are exposed in the Northeast Ox Mountains around Manorhamilton. Where they do not reach the surface, they underlie younger rocks and extend deep into the Earth's crust. These rocks belong to what is called the '**Sliswood Division**'. They are thought to have originated as sedimentary rocks during Precambrian times (2.5 to 4.6 billion years ago). Researchers debate the exact age, with some suggesting that deposition occurred between 750 and 700 million years ago, while others propose a depositional age of 1,700 million years.

These episodes, which developed over tens of millions of years, took place between 600 and 460 million years ago when continents collided, increasing the thickness of the crust. Since they were deposited, they have been repeatedly folded and metamorphosed deep within the Earth's crust as part of mountain-building episodes called orogenies. It produced the banded gneisses we see today at localities such as Benbo.

The first phase of mountain building pushed the Sliswood Division rocks so deep beneath the Earth's surface (approximately 47 km) that they interleaved with mantle material. This mantle material, peridotite, was subsequently metamorphosed to serpentinite, a sliver exposed near Dromahair.

Dalradian rocks: In contact with the Sliswood Division, Dalradian rocks are slightly younger. The connection between the two is everywhere tectonic (*i.e.*, bounded by faults). Both rock units have experienced different depositional and deformational histories. Between 500-430 million years ago, mountain-building episodes brought them side by side. This orogeny, the Grampian, resulted in the deformation and metamorphism of the **Dalradian rocks**. These sediments were converted to metamorphic schists²⁵ as a result. Dalradian rocks are exposed in some locations in Leitrim, most notably near Manorhamilton.

Carboniferous Period (359 to 299 million years ago)

The dominant rock types in Leitrim belong to the Carboniferous classification. These rocks are only mildly affected by folding and metamorphism and retain many of their original sedimentary and depositional structures. Analysis of these features can help us understand this time's changing depositional environments or landscapes. Carboniferous rocks in Ireland are significant economically as they host many valuable mineral deposits; for example, minor examples of such mineral deposits are found in the Leitrim area, *e.g.*, at Twigspark²⁶.

Carboniferous limestones are often easily dissolved by surface water and groundwater. This characteristic has resulted in the development many cave systems and karsts in the Leitrim area (like those seen at Teampall Shetric²⁷, Polticoghlan and Poll na mBear).

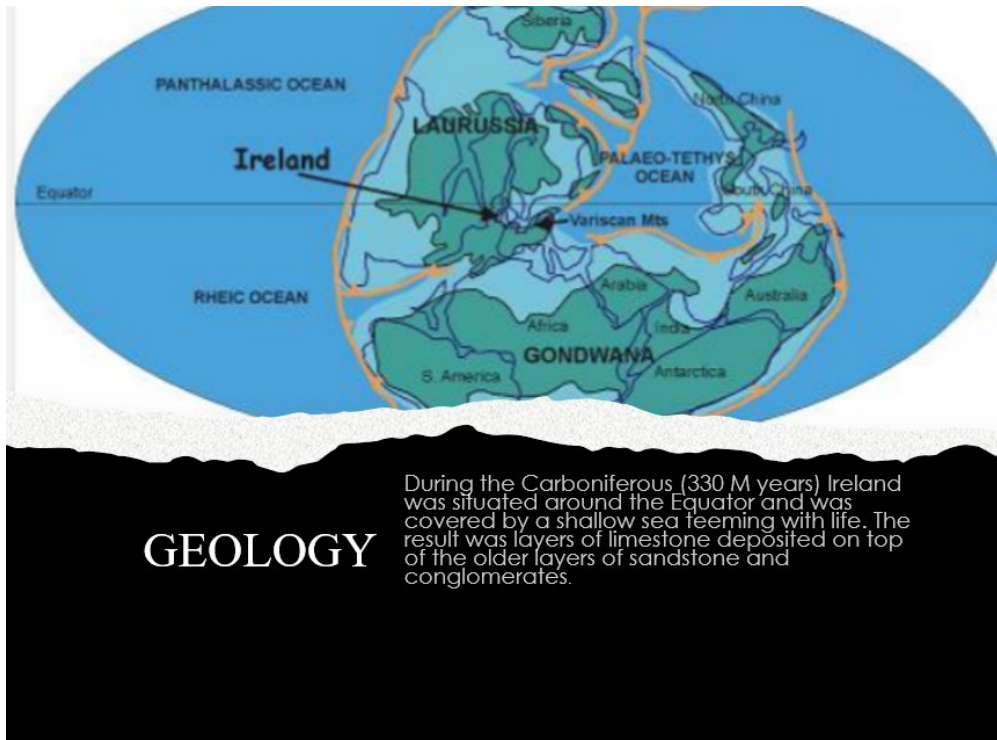
At the beginning of the Carboniferous, the sea level began to rise, sometime after the continental collision that saw the bringing together or alignment of the Sliswood Division and the Dalradian rocks. The shoreline gradually moved northwards, flooding the land as it passed.

²⁵ A rock composed of mineral grains easily seen with a low-power hand lens, oriented in such a way that the rock is easily split into thin flakes or plates.

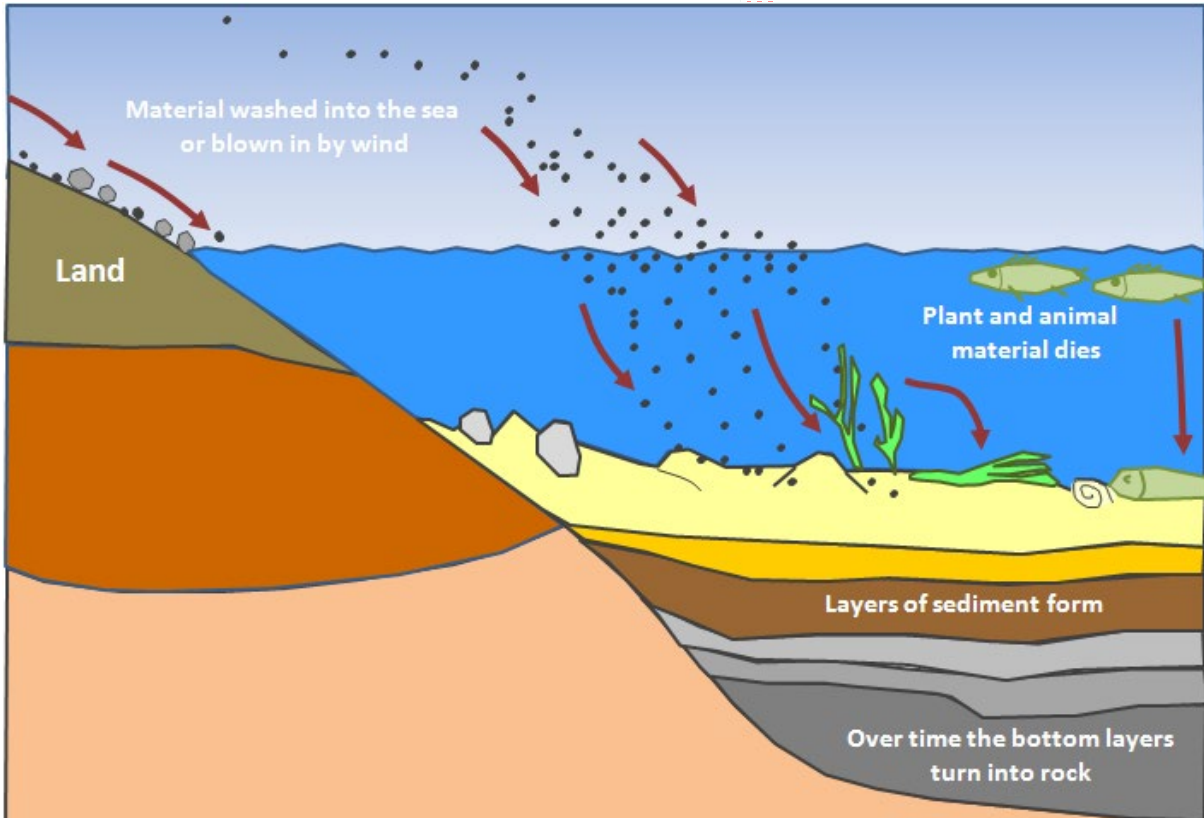
²⁶ <https://www.mindat.org/loc-290558.html>

²⁷ <https://cavesofireland.com/home/caves/teampall-shetric/>

This Carboniferous marine transgression resulted in the deposition of shallow marine sandstones in the Leitrim area. During this time, Ireland had a latitude of 10° and experienced a tropical climate.



The **Bundoran Limestone** was deposited in a clean, shallow, tranquil sea teeming with life. Limestone deposition was interrupted when a significant river delta built out into the tropical sea from a landmass to the north. The northern landmass resulted from the uplift associated with fault movements beneath the Carboniferous rocks. This event saw the deposition of the **Bundoran Shale formation**, followed by the **Mullaghmore Sandstone Formation**, as exposed along the Leitrim coast.



As the delta retreated, the **Benbulbin Shale Formation** (named after its type area at Benbulbin) was deposited. Deposition of the **Glencar Limestone Formation** marked the return to shallow sea conditions. The next period saw the maximum extent of the Carboniferous sea.

Continued fault movement deepened the sea floor in places leading to unfavourable conditions for many forms of marine life. The dark-coloured, largely fossil-free limestones and shales of the **Dartry Formation** (also exposed at Cloontypruglsih) reflect these deep-water conditions. Upstanding features like reefs developed within the deeper water. Lime mud was deposited above these upright structures. A fine example of these mudmounds or mudbanks is found at Carrickbaun Quarry.

The **Bricklieve Limestone Formation** was deposited in shallower water over other parts of Leitrim at this time. As its name suggests, this formation is best exposed on the Bricklieve Mountains, just west of Leitrim.

Sea level began to fall as the landmass to the north was uplifted again. As the shoreline moved southwards again (a regression) the Glenade Sandstone Formation was deposited in a deltaic environment. This deltaic episode left behind a flat landscape over which the sea transgressed and regressed several times, depositing the Bellavally Formation's sediments. The shallow sea deposits of the Meenymore Sandstone Formation mark the beginning of this changing environment.

Glenade sandstone and Meenymore evaporites are well exposed on the summit of Truskmore. The succeeding **Carraun and Dergvone Shale Formations** represent marine depositional environments.

The succeeding **Briscloonagh Sandstone, Gowlaun Shale and Lackagh Sandstone Formations** (at Thur Mountain, Dough Mountain and Slieve Anierin) reflect deltaic, marine and deltaic conditions, respectively. The **Lackagh Sandstone Formation** contains several cyclothem²⁸ or sequences of sandstone, shale, and coal formed simultaneously under deltaic conditions. Thus, the history of coal mining in Leitrim results from depositional events towards the end of the Carboniferous period, approaching 300 million years ago (see Table above).

These coal seams comprise the Connacht Coalfield, one of Ireland's three historic coal-producing regions. For much of the 300 million years following the Carboniferous Period, Ireland was mostly land dominated by erosion rather than sedimentation. There is little evidence in the Irish geological record. At the end of the Carboniferous, the rocks were deformed by the Variscan orogeny. Deformation and metamorphism associated with this mountain-building event were very mild in the country's north.

The relatively quiet interlude geologically was interrupted approximately 75 million years ago when the sea may have covered Ireland. Although no record of this is found in the Leitrim area) and again 60 million years ago as Europe and North America split apart, producing the North Atlantic Ocean. Hot magma rose along fractures and cracks that formed in the limestone in response to this event, cooling to form dykes like those seen near Lough Melvin.

The Ice Ages

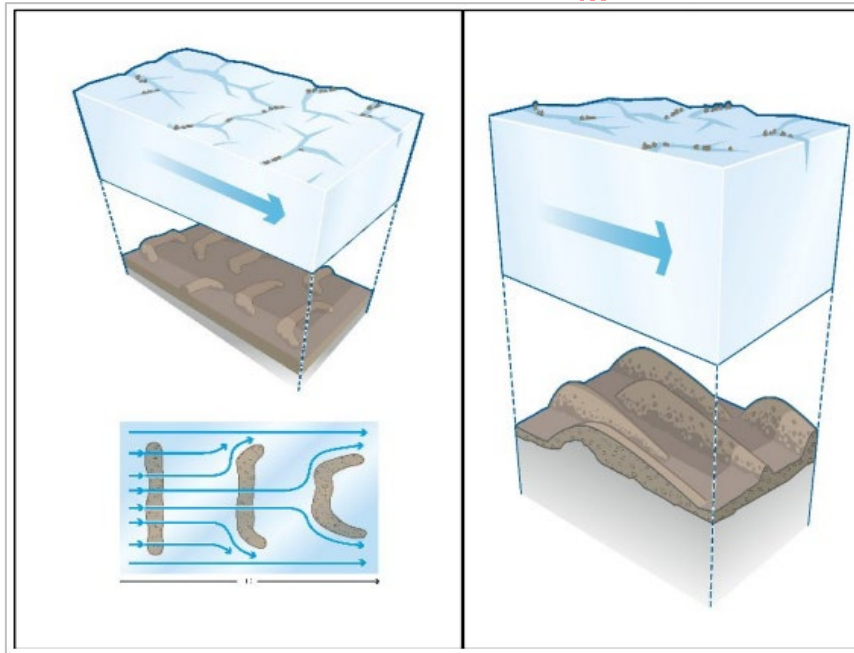
For the last 1.6 million years, Ireland's climate has oscillated between arctic and temperate conditions. A large sheet of ice deposited glacial sediments in Leitrim during the previous Glaciation (the Midlandian), which ended 10,000 years ago. At the maximum extent of the Midlandian Glaciation, ice covered the entire County of Leitrim, reaching thicknesses of up to 650 m.

Earlier glacial and interglacial deposits were either buried by the Midlandian deposits or removed by the large sheet of ice. As the ice moved over the ground, loose debris was incorporated into it, producing an abrasive base to the ice sheet, resulting in an ice-sculpted mountain landscape. The ice also carried large boulders, or erratics, far from their source area.

The ice further sculpted extensive, wide, deep valleys, producing classic U-shaped valleys such as Glenade and Glencar. Their sides expose rocks deposited millions of years before, 'unearthed' by the glacier ice. Towards the end of the last Glaciation, as the ice melted, steepened valley walls, once supported by the ice, collapsed as large-scale landslips like those seen today at Peakadaw and Eagle's Rock in Glenade.

Glacial deposits are thinner in upland areas and thicker in lowland areas. Drumlins, ribbed moraines and crag-and-tails are common glacial features in the Leitrim area. Ribbed moraines are prominent ridges formed perpendicular (*i.e.*, transverse) to ice flow and are effectively large 'chains' of drumlins (see the left-hand panel in the diagram below). Drumlins are low, smoothly rounded, elongated hills formed beneath the ice sheet. Composed mainly of till, their long axis is parallel to the direction of ice flow (*e.g.*, the area around Lough Rinn, near Mohill, see the right-hand panel in the diagram below).

²⁸ Sequences of marine and non-marine sediments, sometimes interbedded with coal seams.



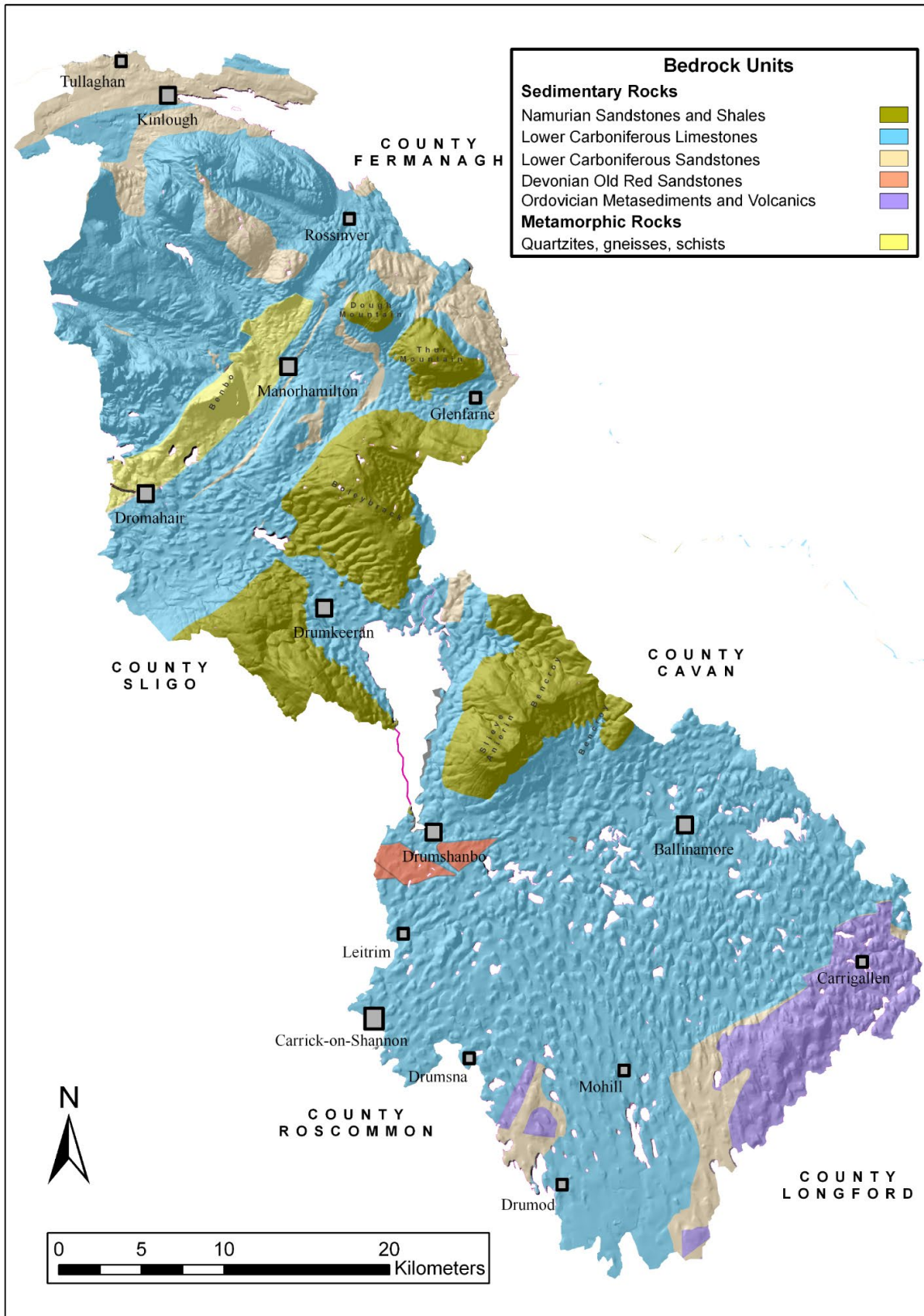
Ribbed moraines forming beneath ice Drumlins forming

The till forming the drumlins of Leitrim is predominantly clayey, meaning that subsoil and soil permeabilities are low and that most of Leitrim's mineral soils are consequently poorly drained or gleyed. Periglacial features such as those seen on Truskmore record the extreme freeze-thaw conditions that shattered and moved the local bedrock towards the end of the last Glaciation.

As the climate oscillated, so too did the sea level. Glacial periods saw the development of large sheets of ice, locking up available water and thus lowering the sea level. Warmer periods melted the ice allowing water back into the oceans and causing the sea level to rise. Wave-cut platforms like those along the Leitrim coast record a post-glacial phase where the sea level was different to what it is today.

During the most recent warm and wet post-glacial phase, peat bogs also spread across uplands and lowlands. This peat, the most common organic soil/subsoil across Leitrim, is also poorly drained, as the peat is a waterlogged material which stores rainfall within its subsurface fibres. Further detail on peat is included when soils are discussed later.





A simplified geology map of County Leitrim outlining the main geological units.

6. THE SOILS OF COUNTY LEITRIM²⁹

The objectives of this report section are

- To provide an introduction to Leitrim’s soils and the implications of their suitability and capacity for food production – primarily based on grass.
- To explore a new approach for considering the soil's potential to deliver a broader range of outputs or ecosystem services.

Introduction

Soil is one of the most critical elements of an ecosystem. It contains both living and non-living components³⁰. It is a biologically active porous medium found on the uppermost layer of the Earth's crust. Soil is formed from the weathering or breakdown of the bedrock under various contributing factors, including living organisms, topography, climate, and geology.

Soil provides a basis for life and is a reservoir of water and nutrients, a structure for the breakdown of organic materials, and supports how these cycle from living (plants) to non-living (water, nutrients). Soils are vital to the life cycles of various land vegetation and soil-inhabiting organisms.

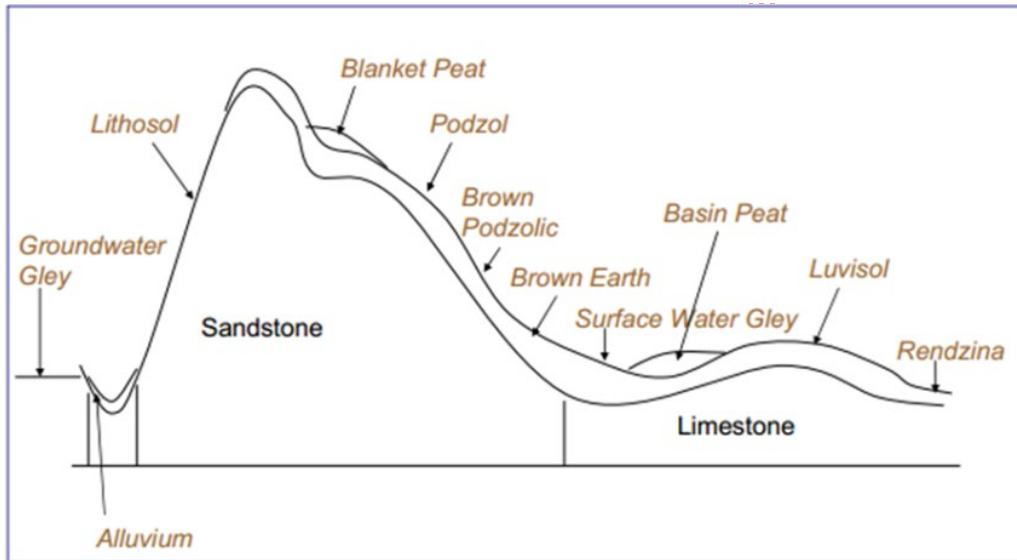
Soils in Ireland are classified into Great Soil Groups depending on their location and formation.

Dominant Identifier	Great Soil Group
Organic Soils – differentiated on the basis of rain fed or groundwater fed systems.	Ombrotrophic and Minerotrophic Peats
Shallow or extremely gravelly soils with a severe limitation to rooting	Rendzina & Lithosol
Soils influenced by water	Alluvial, groundwater and surface water Gleys
Soils affected by Fe/Al chemistry increase	Podzolic/Brown Podzolic
Soils with clay illuviation – clay leached to the sub soil	Luvisols
Relatively young soils with little profile development	Brown Earths

The general locations of the great soil groups in the landscape are shown below, followed by a brief description of each soil type in the Great Soil Group.

²⁹ Owen Carton & Lilian Sullivan, Teagasc, Johnstown Castle, Research Centre, Wexford.

³⁰ <https://microbenotes.com/soil/>



- Peat** is soil made from decomposed organic materials that form over thousands of years. It occurs in wetland ecosystems where plants such as sphagnum moss do not decompose due to the saturated conditions and accumulate over time. They appear under two circumstances. One is **rain-fed peat in either lowland (raised bog) or upland areas (blanket peat)** called **Ombrotrophic Peat**. They have low levels of nutrients, are acidic (pH, 4) and are deeper than 40 cm. Due to high water tables, the other **Minerotrophic peat** or fens are formed in hollows or beside streams. These are more than 40 cm thick and acidic but have a pH >4.
- Lithosols** are shallow acid soils commonly associated with **mountain landscapes**. Generally less than 30 cm deep, they are found on **acidic parent rock** such as sandstone, shale or granite.
- Rendzina** is found on **limestone bedrock in lowland areas**. They are very stony because of the weathering of the parent material close to the surface. The pH is usually more than 6.5.
- Groundwater gleys** are soils with a **high groundwater table**. These soils are found near rivers or inter-drumlin hollows where the water table is high. These soils are waterlogged from bedrock to within 40 cm of the surface for prolonged periods resulting in a grey uniform colour through the profile, called gleying.
- Surface water gleys** are poorly drained due to a slowly permeable subsurface layer. This layer slows down the movement of water through the soil resulting in waterlogging of the top 40 cm for prolonged periods. This slow permeability is due to a higher clay content or dense material in the subsoil. These soils are widely found in Ireland but can dominate part of the drumlin belt and the southwest.
- Podzols** are found at **higher elevations** and consist of a thin peaty layer over poor acidic mineral topsoil. These soils are **developed in cold, wet and acidic conditions** and typically are covered with a heather moor or coniferous forest stand. The organic acids from this vegetation move the nutrients from the upper soil layer to the deeper layers. It produces a distinct banding of dark organic topsoil on a bleached white sandy layer.

- **Brown podzolic** soils have **formed in similar conditions to podzols** but **have not yet developed the poor acidic mineral layer** or the bleached sandy layer typical of podzols. They have a reddish subsoil indicating acidic conditions were present at some stage during their formation. They tend to be free draining. It is sometimes due to management that maintains the topsoil rich in nutrients through additions of manure and fertiliser.
- **Luvisols** are soils in which **clay material from the topsoil has moved down the profile to the subsoil**. They are good agricultural soils; due to their high clay content that retains nutrients well. However, the clay can slow the downward movement of water through the soil so that it can be moderately to poorly drained – depending on the overall texture of the soil.
- **Brown earth** soils are considered the farmer's friend: these soils are **typically free draining and have good nutrient retention**. They are uniform throughout the profile, showing few, if any, layers. The subsoil is generally influenced by the parent rock or glacial drift material on which it is found

In Ireland, the Great Soil Groups can be divided into three broad categories related to their potential food output. They are good, moderately good and marginal. Nationally over 54% of soils (3.74 m ha) are categorised as good or moderately good. The remainder is classified as marginal or difficult. Mountain Hill or Lowland mineral-wet account for 16.7% and 11.8%, respectively, of Irish soils. Both blanket and basin Peats account for the remainder (17.5%).

County Leitrim Resource Survey³¹

Part 1 of the Leitrim Resource Survey – Land Use Potential was published in 1973 by An Foras Taluntais. The report was commissioned in 1971 against the background of:

- Heavy, poorly drained soils and a relatively wet climate. Predominantly grassland farming system that encounters serious problems such as poaching by grazing animals, short grazing season, the necessity for conserving large amounts of winter fodder, and poor trafficability for farm machinery. This latter problem is accentuated by many steep slopes associated with the predominant drumlin topography.
- Farm size is small, off-farm employment is scarce, and the resulting out-migration has created a population structure dominated by the old and very young.

It was recognised that positive agriculture and rural development progress could be made based on an inventory of the County's resources. It would allow recommendations to be made on alternative land use systems to improve the welfare of the people of Leitrim.

The objectives of the survey were:

- To provide basic information on Leitrim's physical, economic and sociological resources against which the principal rural problems of low farm income and high population decline could be analysed.

³¹ <https://www.teagasc.ie/media/website/environment/soil/Leitrim-report-1.pdf>

- To assess the optimum land-use enterprises for Co. Leitrim, bearing in mind the predominant soils and climate.
- To assess the potential for development within the County of a stable population where farm incomes would reach at least a minimum acceptable viable level.
- Assess the potential for tourist income development as this was directly related to agriculture, e.g., farm guest houses, fishing, and boating.

There were 18 Soil Series³² identified and mapped in the survey. The different series were given names based on the geographic locations where they were found. For example, there are six gley soil series called Ballinamore, Drumkeeran, Ciarvagh, Howardstown, Kiltyclougher and Rinnagowna.

The Leitrim soil map is shown below. The map shown is the recently updated version of the Irish Soil Information System project³³. It conducted a structured research programme into the national distribution of soil types and developed a soil classification system which identified and described Irish soils using a consistent national legend.

The Table below classifies Leitrim soils based on the lead soil in the soil association into the three management categories, the Great Soil Groups, and their soil suitability for farming (production) broadly based on the data from the Leitrim Resource Survey³⁴.

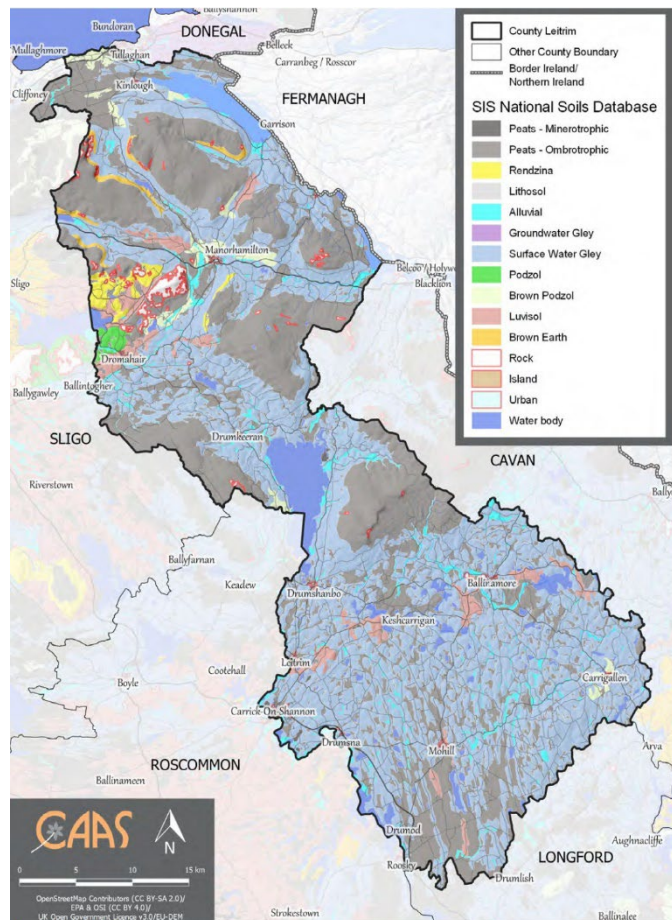


Figure 4.8 Soil Type

³² A group of soils with similar profiles developed from similar parent materials under comparable climatic and vegetational conditions.

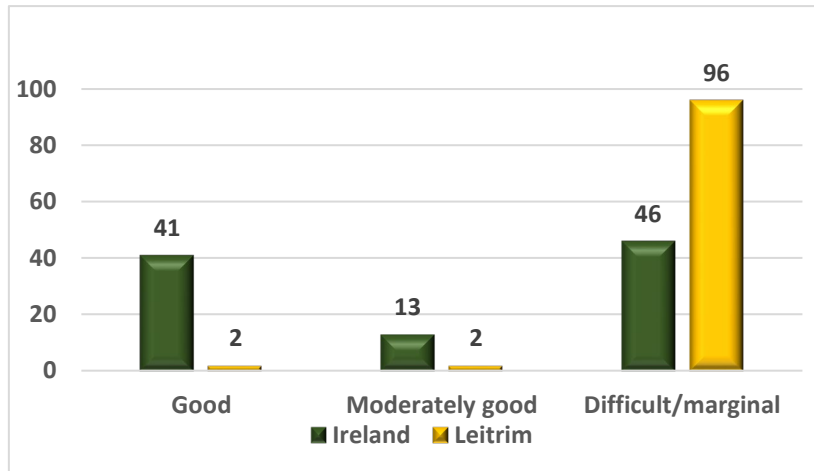
³³ <https://www.epa.ie/publications/research/land-use-soils-and-transport/research-130-irish-soils-information-system.php>

³⁴ <https://www.teagasc.ie/crops/soil--soil-fertility/county-soil-maps/>

Category	Great Soil Group	Percent area of County Leitrim	Total area (ha)	Soil Suitability for Farming
Good (1.5%)	Luvisols/	0.48%	715	<p>Luvisols - High elevations, steep slopes and shallowness severely limit the range of these soils.</p> <p>Rendzina – shallow - free draining, 30% well suited to grassland but the remainder on elevated & rugged topography with rock outcrops – best suited to extensive grazing</p>
	Rendzina	0.95%	1,429	
	Brown Earths	0.15%	222	Because of the steep slopes and the weak soil structure, sheep grazing forms the leading farm enterprise. The soils are inherently fertile and will respond to fertilisation.
Moderately Good (1.9%)	Grey Brown Podzolic	0.21%	317	<p>Grey, Brown Podzolic - Well drained but impeded in flat areas and depressions. Large sandstone boulders are common. High potential for grass production.</p> <p>Brown Podzolic - The desirable texture, structure, consistency, and natural drainage make them very suitable for grassland farming. Those on drumlins may have a reduced capacity due to poaching in heavy rainfall periods. Nutrient management to maintain soil pH and fertility is necessary.</p>
	Brown Podzolic	1.8%	2, 827	
Difficult/ Marginal	Podzol	0.48%	715	These soils have a limited use range. As a result of extreme podzolisation, natural lime and nutrient status are extremely low.
	Lithosols	0.45%	715	<p>Lithosols - High elevations, steep slopes and shallowness severely limit the range of these soils - are mainly suitable for extensive sheep grazing.</p> <p>Gleys - They are moderately suitable for grassland farming and ideal for forestry.</p>
	Gleys	57.4%	85,989	

	Peat – fen	10.7%	15,034	<p>Fen- Where drainage is adequate, these soils are suitable for grassland farming and vegetable growing. The main problems are frost hazards, high water table during winter and spring, and low base status.</p> <p>Raised bog - in its natural state, where no physical "ripening" (<i>i.e.</i>, loss of water and aeration of the profile) has taken place, a raised bog is primarily unsuited to any agricultural enterprise.</p>
	Raised bog peat	5.05%	7,575	
	Peat – Blanket	22.55%	33,792	Best suited to extensive grazing. Their organic nature and elevation are the main challenges.

The figure below broadly contrasts the three categories of Leitrim soils with those nationally. It shows that most of Leitrim's grounds are in the difficult/marginal category compared with Irish soils utilising the land use potential framework in the County Leitrim Resource Survey. It should be noted that the classifications below are based on reports from the 1970s. If the most recent research were applied it will give slightly different numbers but the trends will be similar.



Soil Suitability

The Leitrim Resource Survey groups soils using a soil suitability survey. The approach grouped soils according to potential use or uses for which they can be most adaptable. It is based on the significance of the soil's characteristics and provides an assessment of the production potential of each soil type for the normal range of farm crops. Soil suitability offers a link between the physical characteristics of the soil to the economic aspects of their use. Although the survey is dated, it is considered here without any more recent evaluation survey. While many socio-technical factors and scientific knowledge related to land use and management have progressed in the interim, essential biophysical characteristics will remain essentially unchanged.

The primary elements in assessing soil suitability are physical, chemical, and biological properties. Environmental factors such as elevation, aspect, local climate, accessibility, and consumer demands must be considered.

The report, based on the soil map, concluded that:

- 8.4% of soils were good to very good for grassland
- 2% were moderate to very good for grassland
- 48% were poor to very poor for grassland
- 36% - mainly peats – whose suitability in their natural state is poor.

It also assessed only 4% of soils were suitable for tillage, while 54% were poor to very poor. Poorly drained soils account for 84% of the County. In addition, the Leitrim climate, with its high incidence of rain days and lower sunshine hours compared with the country's main tillage areas in the southeast, are less conducive to tillage enterprises.

Grazing Capacity

The resources survey also assessed the grazing capacity of Leitrim's soils. It was based on grass production and utilisation within the County. In 1971, the average stocking rate for the County was

0.59 livestock units (LU) per ha, with considerable within-county variation based on soil type. For example, on mountains/ areas in the north, 0.25 LU per ha to 0.77 LU per ha in the south.

Lee & Diamond³⁵ estimated that the potential grazing capacities of Leitrim's soils could be increased to between 1.46 and 1.54 LU per ha on lowland and hill soils with nitrogen inputs of 48 kg per ha and 230 kg per ha, respectively. It was concluded that the number of livestock in Leitrim could be doubled – indicating a significant potential for the sector's development.

The renewed interest and awareness of soils is a result of the increased demand for food production to meet the demands of the continuing growth in global population. There is greater awareness and a rapidly increasing knowledge base of the other soil functions including water purification, carbon sequestration, habitat biodiversity and nutrient cycling. Soils do not have the same legislative protection as water and air. Therefore, it is essential to raise awareness of the role of soils by improvements in the knowledge exchange or communications between scientists, policy makers, farmers, land managers and the public to ensure that measures are put in place to protect soils and reduce further soil degradation.

Leitrim Soils - Their multifunctional opportunities

The proceeding section outlined the results of the 1973 soil survey and their land use potential. It identified:

- The Leitrim landscape is made up of drumlins that form part of the northwest drumlin belt. Drumlins formed when the unsorted glacial drift was deposited as the ice retreated at the end of an ice age.
- The drumlin topography is associated with heavy wet soils such as Surface-water Gleys (slowly permeable sub-surface layer) occurring in glacial drift deposits. Between the drumlins, basin peat is a common feature.
- The wet climate and poorly draining soils result in a relatively short grazing season and poaching issues, which means that farming can be unforgiving in this part of the country.
- Lough Allen provides a natural divide to the County. The northwest is hilly and mountainous compared to the southeast, which is relatively flat. As well as the drumlins, there are pockets of blanket peat located east, west and south of Manorhamilton. Blanket peat is also found in border locations east and west of Lough Allen. Lowland raised bog, with some industrial peat activity, is located south of Mohill.
- Both peat types continued growth due to rainfall, topography, and the groundwater table position. Overall, peat is a significant feature of the Leitrim landscape, particularly in the upland areas in the County's northern half.

³⁵ <https://www.teagasc.ie/media/website/crops/grassland/heavy-soils/1974,-Land-potential-for-grazing-in-Ireland,-Lee.pdf>

- Poor drainage is a significant problem in Leitrim, with water-affected soils accounting for almost all soils. Surface-water Gleys and Humic Surface-water Gleys dominate the landscape. 'Gleys' are soils affected by seasonal or continuous waterlogging. They form due to a slowly permeable sub-surface layer associated with a heavy textured subsoil resulting in poor drainage. It gives rise to a greyish colour.
- The combination of heavy, poorly drained soils and a relatively wet climate imposes natural limitations on production agriculture. It dictates a predominantly grassland farming system which encounters serious problems such as poaching by grazing animals, short grazing season, the necessity for conserving large amounts of winter fodder, and poor trafficability for farm machinery. This latter problem is accentuated by many steep slopes associated with the predominant drumlin topography.

Functional Land Management

A new framework – Functional Land Management (FLM)³⁶ - offers an exciting opportunity to develop Leitrim's soils' outputs beyond food production. It is based on the concept that:

- Soils deliver multiple functions simultaneously.
- Some soils are better at providing certain soil-based ecosystem services than others.

FLM focuses on a range of soil functions – often called ecosystem services - delivered by soils. They include, amongst others:

- Primary productivity,
- water purification and regulation,
- Carbon cycling and storage,
- Habitat for biodiversity
- Cultural heritage
- Recreation and Human Health.

An initial attempt was made to link the capacities of the Great Soil Group to deliver these ecosystem services. The objective was to provide a platform for exploring the concept within Leitrim's communities of how these new ecosystem services, combined with the County's rich natural and cultural heritage, can contribute to farming and rural development.

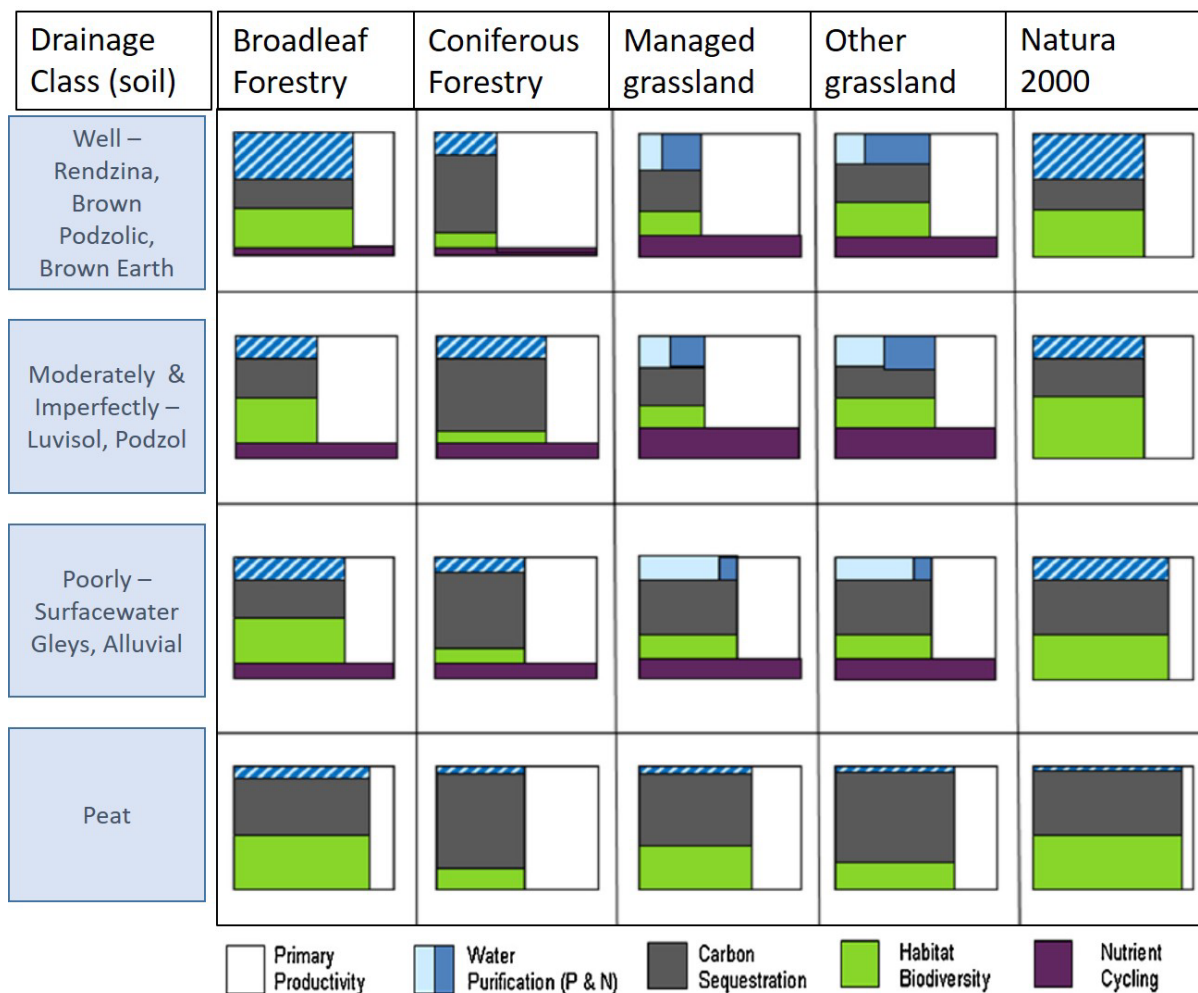
The allocation of services to each soil group is arbitrary, based on the author's experience. The suitability of a particular soil group to deliver a specific service is relatively expressed as High, Medium or Low.

³⁶ Schulte, R.P.O., R. Creamer, T. Donnellan, N. Farrelly, R. Fealy, C. O'Donoghue, and D. O'hUallachain. 2014. Functional land management: A framework for managing soil-based ecosystem services for the sustainable intensification of agriculture. *Environmental Science & Policy* 38: 45–58. <https://doi.org/10.1016/j.envsci.2013.10.002>.

As noted in the Soils Suitability section above, many other factors will influence the soil's potential to deliver a particular group of services. They include environmental factors such as elevation, aspect, local climate, factors such as accessibility, and consumer demands. Equally and possibly, more importantly are the ambitions and interests of the land manager.

Multifunctional matrix showing the relative potential of the suite of soil functions under different land use combinations (x-axis) typically found in Leitrim and soil drainage class (y-axis) and associated soil types. Matrix-based upon relative delivery from Coyle et al. (2016)³⁷.

The figure below highlights the beneficial contribution of soils towards selected soil functions governed by soil and management factors. For example, peat soils, which occupy a high prevalence in Leitrim, are essential for carbon cycling but have limited potential to accept and recycle external nutrients. In contrast, less intensively managed grasslands on well or moderately-drained soils generate a broader blend of soil functions. Importantly, this shows the variable capacity to deliver soil-based ecosystem services. The table below further expands on this concept.



³⁷ <https://www.sciencedirect.com/science/article/pii/S1462901115300952>

Great Soil Group	Drainage class	Food	Water	Carbon	Habitat	Heritage	Recreation & health
Rendzina	Free draining	Good pasture but limited by rooting depth for other crops.	Moderate- good water regulation potential in excess moisture conditions.	Low but increases in the presence of peats.	Moderate (grassland) Low (coniferous forest).	Site-specific.	High when found at higher locations.
Luvisols	Moderate	Moderate (where poor drainage due to texture) – High (clay enrichment).	Moderate	Moderate – High			
Brown Earths	Free draining	High					
Brown Podzolic	Moderate	Dependent on land use			Low		
Podzol	Moderate						
Lithosols	Imperfectly			High			

Gleys	Poor						
Peat – fen Raised bog peat	Poor	Low	High	High	High	Low	Low
Peat – Blanket	Poor			High			

This initial assessment provides a basis for developing a new vision for a multifunctional farming model. The additional ecosystem services offer a much more significant input for tourist income development than that envisaged almost 50 years ago when Part 1 of the County Leitrim Resource was first published.

Consideration should be given to providing a better evidence-based study to support and refine the allocation of ecosystem services to the Soil Groups.

Soil health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. Healthy soil gives us clean air and water, bountiful crops and forests, productive grazing lands, diverse wildlife, and beautiful landscapes. Soil does all this by performing five essential functions:

- *Regulating water* – Soil helps control where rain, snowmelt, and irrigation water goes. Water flows over the land or into and through the soil.
- *Sustaining plant and animal life* – The diversity and productivity of living things depends on soil.
- *Filtering and buffering potential pollutants* – The minerals and microbes in soil are responsible for filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposits.
- *Cycling nutrients* – Carbon, nitrogen, phosphorus, and many other nutrients are stored, transformed, and cycled in the soil.
- *Providing physical stability and support* – Soil structure provides a medium for plant roots. Soils also provide support for human structures and protection for archeological treasures.

Soil health research has determined how to manage soil in a way that improves soil function.

The main principles to manage soil for health are:

- Maximize Presence of Living Roots
- Minimize Disturbance
- Maximize Soil Cover
- Maximize Biodiversity

As world population and food production demands rise, keeping our soil healthy and productive is of paramount importance. By farming using soil health principles and systems that include no-till, cover cropping, and diverse rotations, more and more farmers are increasing their soil's organic matter and improving microbial activity. As a result, farmers are sequestering more carbon, increasing water infiltration, improving wildlife and pollinator habitat—all while harvesting better profits and often better yields.

Further useful information on soil health can be found at

https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/?cid=nrcs142p2_053846

Wetlands can be defined as areas where the water table is at or near the surface, permanently, or on a seasonal basis. Wetlands can be natural (e.g., marsh) or artificial (e.g., quarry pond) and can also range from freshwater (e.g., rivers), to brackish waters (e.g., estuaries), to marine (e.g., rocky shore).

Leitrim has wetland habitats ranging from raised bogs, turloughs, fens, marshes, rivers and associated floodplains, lakes, springs, wet woodlands, and a limited number of coastal habitats. The range reflects the county's varying topography, geology, hydrology, climate, and soils.

The County Leitrim Wetland Survey 2019 developed a database of all freshwater wetland sites in the county.

The study focused on the identification of 38 wetland habitat types (26 of which may correspond with habitats listed on Annex I of the EU Habitats Directive) and provided a preliminary inventory of the wetland resource in the county.

The area of wetland sites mapped covered an area of 375 km² (23.5% of land area).

Of the wetland sites identified in Leitrim, 33 are within areas designated for nature conservation while the remaining 337 are outside of designated areas. A significant proportion of these undesignated sites, most of which have not been subject to ecological survey, are likely to support habitats and species of conservation importance.

Our incomplete knowledge of 269 of the wetland areas in County Leitrim, which have not been subject to any detailed ecological survey, suggests that a targeted wetland survey should be a key priority to gain a better understanding of the wetland resource within the county and to ensure that those sites of highest importance are protected.

<https://storymaps.arcgis.com/stories/4415f51e1311437f8f0f5c7be4cdb90c>

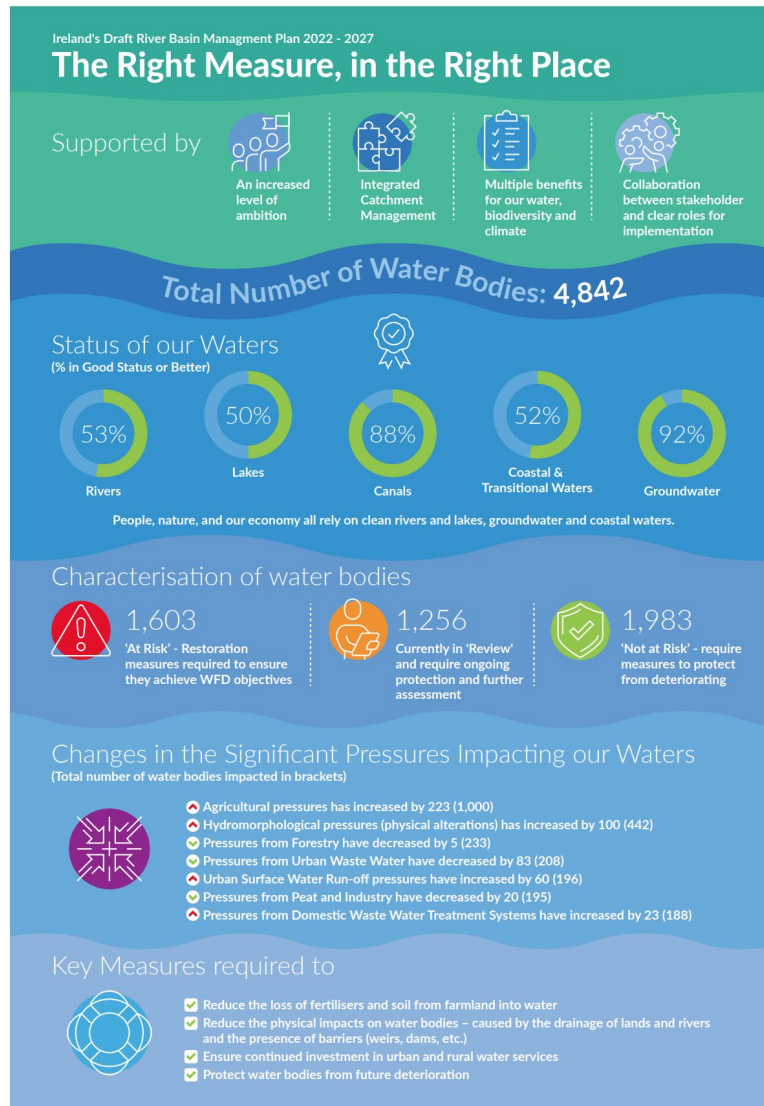
<http://www.leitrimcoco.ie/eng/Community-Culture/Heritage/Publications/Leitrim-Wetland-Survey-2019-Report.pdf>



7. WATER

Introduction

The draft River Basin Management Plan (RBMP) for Ireland 2022 – 2027³⁸ summarises the status of Irish water quality, outlines the risk characterisation of waterbodies, the pressures on water and the key measures required to address the risk.



The report describes water as the foundation of sustainable rural and urban life, the core of a thriving society. Well-managed and protected water catchments provide vital ecosystem services or public goods:

³⁸ <https://www.gov.ie/en/consultation/2bda0-public-consultation-on-the-draft-river-basin-management-plan-for-ireland-2022-2027/>

- Reliable, clean water to drink.
- Sanitation.
- Protection against flooding.
- Support for biodiverse ecosystems.
- Climate mitigation.

After many years of steady improvement, Ireland is now experiencing a sustained decline in water quality³⁹. In addition to improving overall water quality, sustainable water management is essential to addressing and adapting to the impacts of climate change, with many of the required measures having co-benefits for climate mitigation and biodiversity.

Protecting and restoring water quality in Ireland will need measures to address the loss of agricultural nutrients to the water, improve wastewater treatment, and re-establish natural free-flowing conditions in more rivers.

Ireland has abundant natural water resources in rivers, lakes and groundwater. These water resources have inherent and indisputable value but provide essential ecosystem services. Clean, plentiful, and well-protected water is vital for the continuing success of Ireland's society and economy.

Ireland's drinking water relies primarily on rivers and lakes, which must be protected from pesticides, excess nitrogen and discharges of pollutants of concern (including micro-pollutants). Groundwater must be protected from chemical pollution and especially from excess nitrates.

Our food industry trades on Ireland's image as a clean and green source of sustainable food production. Ireland's tourism industry relies on our image as a green island with well-stocked, healthy fisheries, unpolluted estuaries without green algae, and clean beaches next to good-quality bathing waters.

As a result of the Green Deal (*c.f.*, Policy section), the EU Commission is reviewing water legislation, including directives on urban wastewater, bathing water, environmental quality standards for water, industrial emissions, and sewage sludge.

The 2020 Programme for Government⁴⁰ contains a significantly more ambitious programme for the environment. Under the 'Green New Deal, a comprehensive range of actions is outlined, including for water, natural heritage and biodiversity, climate and environmental emissions. The need for an integrated approach to these issues is recognised, including the potential to deliver integrated measures which benefit all ecological objectives.

United Nations Sustainable Development Goal 6 The 2030 Agenda for Sustainable Development⁴¹, adopted by all Member States in 2015, provides a shared blueprint for peace and prosperity for people

³⁹ <https://www.epa.ie/our-services/monitoring--assessment/assessment/irelands-environment/water/current-trends-water/>

⁴⁰ [gov.ie](http://www.gov.ie) - Programme for Government: Our Shared Future (www.gov.ie)

⁴¹ [21252030 Agenda for Sustainable Development web.pdf \(un.org\)](https://www.un.org/sustainabledevelopment/)

and the planet. At its heart are the 17 integrated Sustainable Development Goals (SDGs). SDG 6 is to 'ensure availability and sustainable management of water and sanitation for all.

These goals have been integrated into the measures and the governance arrangements for the proposed River Basin Management Plan 2022 - 2027.

The Water Framework Directive (WFD)

The Water Framework Directive (Directive 2000/60/EC) is EU legislation regulating European water management. Member states adopted the Directive across Europe in 2000. It requires, by 2027 at the latest, that

- All waters (rivers, lakes, groundwater, estuaries, coastal water, canals and reservoirs) are protected.
- Measures are put in place to ensure the quality of these waters is restored to at least 'good' status or good potential (with some narrow exceptions)

The Directive governs all activities that may impact this objective or the quality or quantity of water. The Directive requires an integrated approach (*i.e.*, across all sectors, including agriculture, industry, spatial policy *etc.*) to the sustainable management and protection of water resources. Member states are required to set out how they will achieve these objectives in RBMP. These plans are prepared in six-year cycles, during which actions must be implemented to achieve the water quality objectives.

The Directive is linked to and reinforces other EU environmental directives, including directives relating to the protection of biodiversity (Birds and Habitats Directives), directives related to specific uses of waters (drinking water, bathing waters and urban wastewater directives) and directives concerned with the regulation of activities undertaken in the environment (Industrial Emissions and Environmental Impact Assessment directives). The Nitrates Directive also forms an integral part of the Directive and is one of the critical instruments in protecting waters against agricultural pressures.

Of all the water on Earth, just 3% is fresh water and only 1% is readily available for human use and for nature that depends on it. Ireland's surface water resource is comprised of 84,800 km of mapped river channel, 12,000 lakes (EPA Ireland)



Integrated Catchment Management (ICM)

A water catchment (or 'river basin') is an entire area of land from which surface water run-off flows until it reaches a river, lake, groundwater or the coast. There are various catchment types and sizes. In Ireland, the development and implementation of the RBMP are achieved through an ICM approach.

It uses the catchment, sub-catchments and water bodies as the functional areas and units of the Plan. Using catchments, sub-catchments and water bodies to examine the pressures on our water resources at an appropriate scale allows us to manage our waters effectively.

It also brings together all public bodies, communities and businesses connected with these catchments. The process involves,

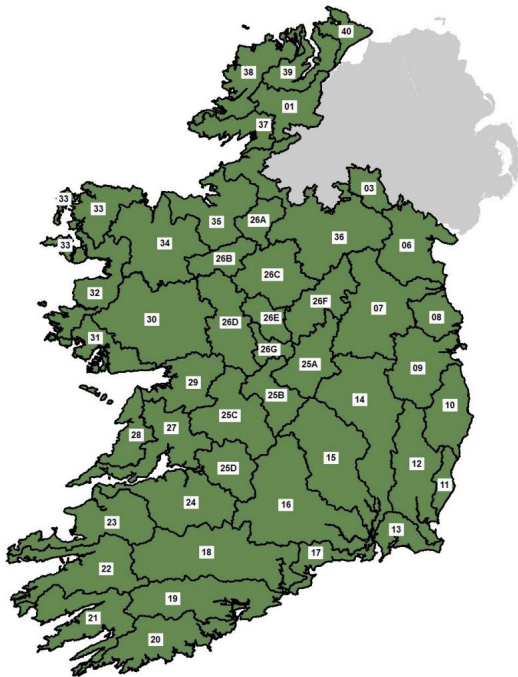
- Gathering the best available information to understand the catchment - where the water comes from, how it flows through the landscape and the activities that may be causing pollution.
- Looking at all the uses of water - drinking, agricultural, industrial and recreational, and also the ecosystems that depend on water to survive.
- Engaging local communities and involving them in the management of their catchment.

- Adopting appropriate measures to ensure that activities representing a significant threat to water resources are effectively managed.
- Applying the scientific and local knowledge of how the catchment operates to protect and improve water provides a healthy, resilient, productive, and valued resource that supports vibrant communities.

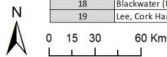
Waterbody Type	No. of Waterbodies
River	3192
Canal	16
Lake	812
Coastal	112
Transitional	196
Groundwater	514
Total	4,842

Ireland's RBMP planning process is based on a single national River Basin District. It covers an area of 70,273 km² and is broken down into **46 catchment management units** (see map below). The 46 catchment management units have been further subdivided into 583 sub-catchments with 5 and 15 waterbodies in each. There is a total of 4,842 waterbodies made up of six types.

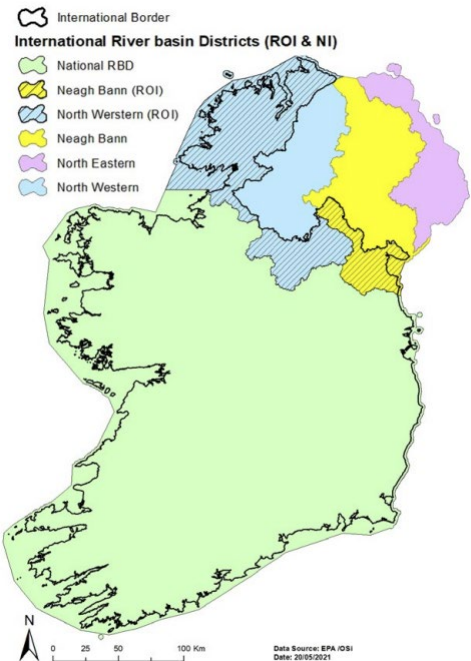
What is a waterbody? A waterbody is an individual unit of a water feature used for monitoring and planning purposes. For example, in groundwater this is part of an aquifer. For surface water, this is a discrete and significant element of surface water, such as part of a stream, river or canal, a transitional water, or a stretch of coastal water. There are various types including a body of surface water, a body of groundwater and artificial water bodies.



Catchment No.	Catchment Name	Catchment No.	Catchment Name	Catchment No.	Catchment Name
01	Foyle	20	Bandon-Ilen	26G	Upper Shannon
03	Lough Neagh & Lower Bann	21	Dunmanus-Bantry-Kenmare	27	Shannon Estuary North
06	Newry, Fane, Glyde and Dee	22	Laune-Maine-Dingle Bay	28	Mal Bay
07	Boyne	23	Trillick Bay-Faile	29	Galway Bay South East
08	Nanny-Deavin	24	Shannon Estuary South	30	Corrib
09	Liffey and Dublin Bay	25A	Lower Shannon	31	Galway Bay North
10	Ovoca-Vartry	25B	Lower Shannon	32	Erriff-Clew Bay
11	Owenaweragh	25C	Lower Shannon	33	Blacksod-Broadhaven
12	Slaney & Westford Harbour	25D	Lower Shannon	34	Moy & Killalea Bay
13	Ballyteigue-Bannow	26A	Upper Shannon	35	Sligo Bay & Drowse
14	Barrow	26B	Upper Shannon	36	Erne
15	Nore	26C	Upper Shannon	37	Donegal Bay North
16	Suir	26D	Upper Shannon	38	Gweebarra-Sheephaven
17	Colligan-Mahon	26E	Upper Shannon	39	Lough Swilly
18	Blackwater (Munster)	26F	Upper Shannon	40	Donagh-Moville
19	Lee, Cork Harbour and Youghal Bay				



Data Source: EPA / OSI
Date: 20/05/2021



Data Source: EPA / OSI
Date: 20/05/2021

The 46 Irish Catchment Management Units

[Catchments.ie](https://catchments.ie) - Water, from source to sea. The website is managed by the Department of Housing, Local Government and Planning, the Environmental Protection Agency, and the Local Authority Waters Programme. It provides substantial background information, the most current and up-to-date information on the status of your local rivers, lakes, and waterbodies. Information on how these valuable resources is being used and the environmental pressures they are subject to, is also provided through specific Catchment and Sub-Catchment Assessment

Ireland shares two river basin districts (RBD) with Northern Ireland. The Neagh Bann International RBD has 35 shared waterbodies, and the Northwestern International RBD has 85.

Important areas lie within cross-border river basins in Ireland, with waters in each jurisdiction flowing into or through the other jurisdiction. The waterbodies from these RBD in Ireland are managed as part of the single national RBD. Both jurisdictions are responsible for ensuring implementation of all measures in their national territory, including any part of an International RBD within their region.

The 2022 – 2027 DRBMP for Ireland outlines estimates of the scale of mitigation measures required to improve water quality significantly

The theme for the 2022- 2027 draft RRBMP includes

- A high level of ambition with clear strategies to protect those still at good status or above and improve water bodies that are at less than good status.
- Fully integrated catchment management plans – the initial levels of detail to be included in these plans will be decided based on templates produced by LAWPRO in consultation with stakeholders.
- Each Local Authority will also prepare a County level Implementation Plan as part of this process to give action to the objectives of the national and catchment plans.
- These plans will also provide a basis against which to assess the implementation of measures through annual reports.
- Many of the measures have multiple benefits, including climate change and biodiversity.

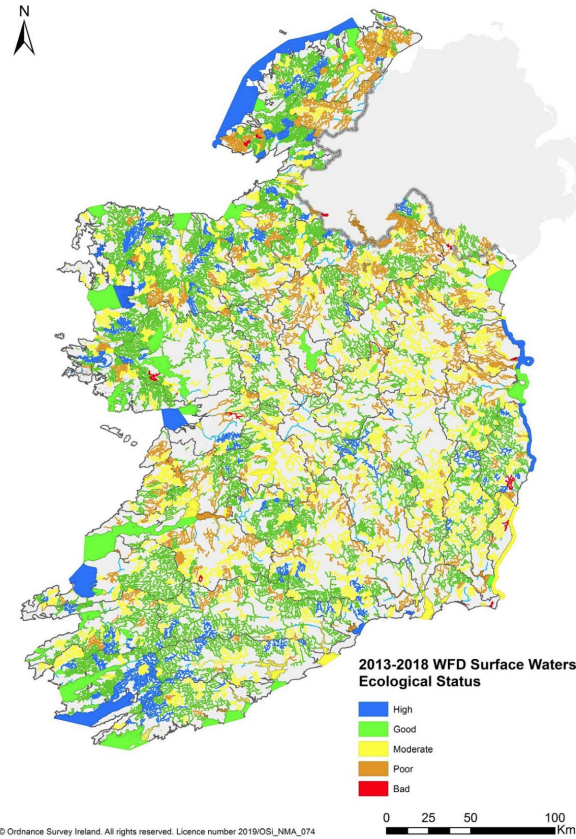
The draft RBMP, for the first time, includes detailed estimates of the scale of mitigation measures required to improve water quality and where they need to be deployed. For agriculture the key mitigation measure is at least a 50% reduction in nitrogen losses to waters from agriculture. The latter is referred to "right measure in the right place".

The Status of Irish Waters (2016-2021)

From 2013-2018⁴² 2,718 surface waterbodies were monitored for ecological status. There were a further 514 groundwater bodies assessed for groundwater status. The numbers of surface waterbodies achieving high, good, moderate, poor and bad status in each waterbody type are outlined in the Table below. The location of these water bodies and their corresponding status can also be seen in map below

Waterbody Type	Status					Total per waterbody type
	High	Good	Moderate	Poor	Bad	
Groundwater	-	474	-	40	-	514
Coastal	10	26	9	-	1	46
Transitional	7	23	30	14	6	80
Lake	17	96	72	28	11	224
Canal ¹	-	14	1	1	-	16
River	196	1052	653	442	9	2352
Total	230	1685	765	525	27	3232

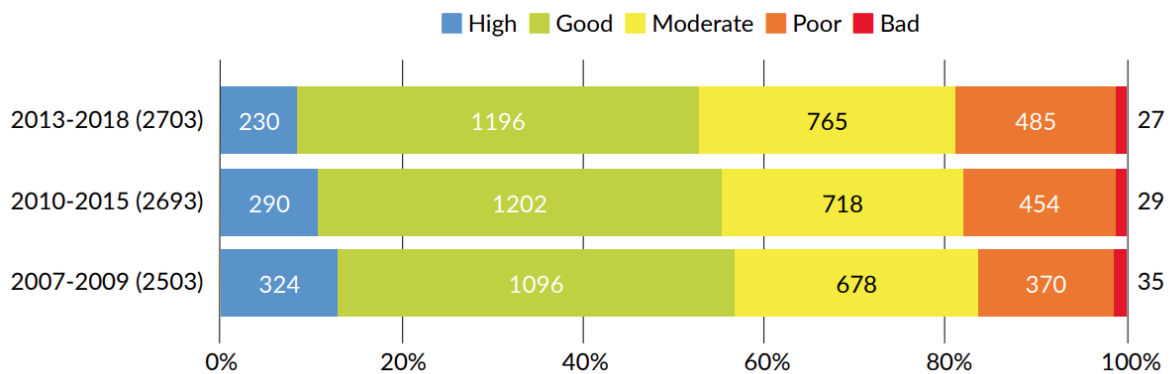
⁴² [Monitoring & Assessment: Freshwater & Marine Publications | Environmental Protection Agency \(epa.ie\)](#)



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There was an overall 4.4% net decline in surface water ecological status between the first and second assessment periods, driven mainly by the decline in the status of river waterbodies. The status change over the three assessment periods for all surface waters is outlined in the Table and figure below.

Category	Stable	Declined	Improved	Net Change
Rivers	1,612	429	301	-128
Lakes	150	30	42	12
Transitional	47	13	10	-3
Coastal	22	9	11	2
Total	1,831	481	364	-117
Percentage	68.4%	18.0%	13.6%	-4.4%

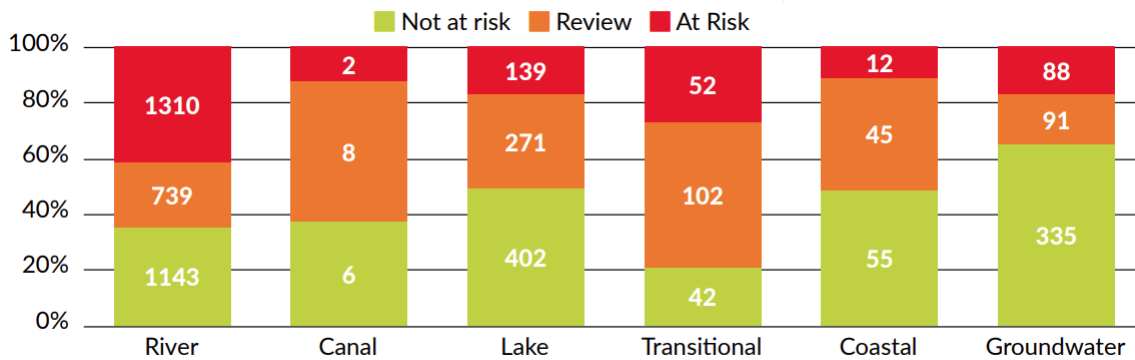


Assessment of biological river water quality in 2019 and 2020 indicates some recovery in water quality, with more rivers showing improvements than declines. Provisional results also show that the proportion of rivers improving in quality in the Priority Areas for Action (PAA) at 21% is higher than the proportion improving outside of these areas at 13%, indicating that the targeting of actions is helping to enhance the quality of water. Nevertheless, many river waterbodies are still declining and unless this is addressed, sustained and progressive improvements in water quality will be difficult to achieve

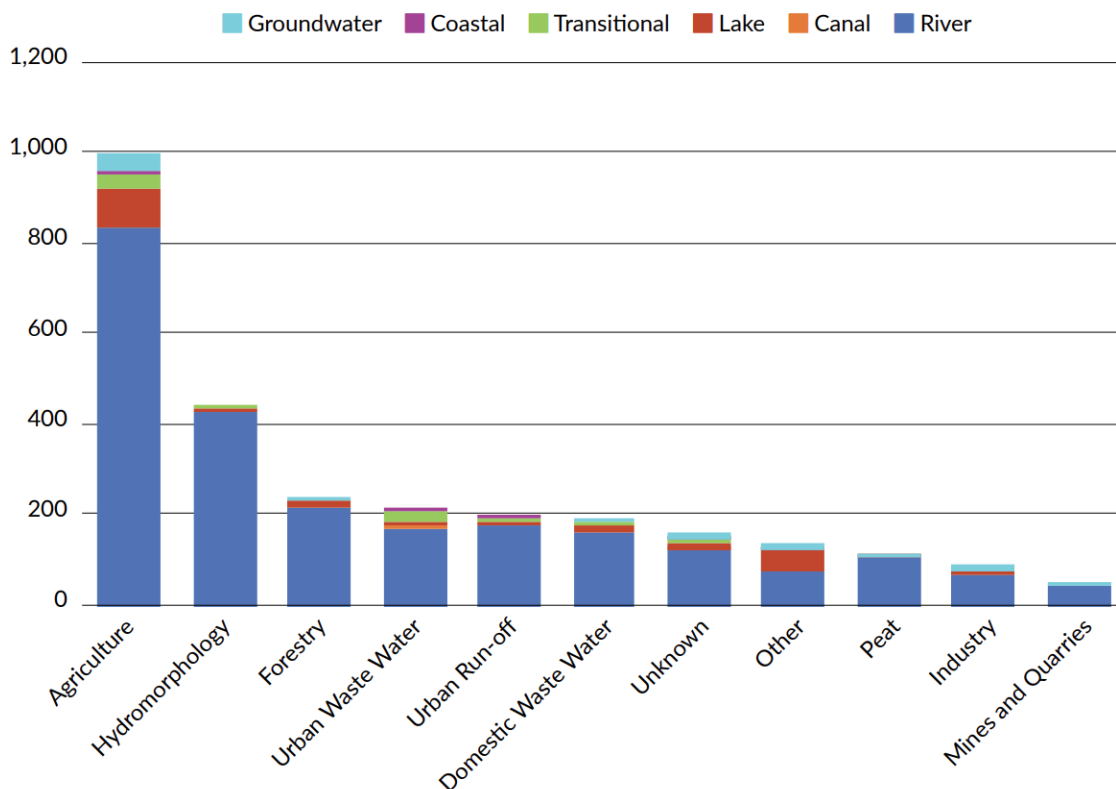
The third cycle of the Water Characterisation Assessment was undertaken across 4,842 waterbodies by the EPA, with input from the Local Authority Waters Programme/Local Authorities and members organisations of the five Regional Operational Committees. The assessment showed:

- 41% are within the **Not at Risk** category, meeting their environmental objective of good or high status.
- 33% are **At risk** of not meeting their environmental objective of good or high status. The significant pressures for each waterbody were also identified.
- 26% are currently **in review**, which means that either
 - (1) The measure(s) is in place, but the water quality improvement has not yet been realised, or there is some improvement but not enough to put it at Not at Risk, or more commonly.
 - (2) There is currently inadequate evidence to determine whether or not the water body is At risk. A review of the available evidence and the collection of new evidence is ongoing to reduce this number over time.

The breakdown of the waterbody risk category for each waterbody type is shown below.



The next step of the process was to establish the **significant pressures** on water bodies. Agriculture is the most common significant pressure impacting 1,000 water bodies, followed by hydro morphology (physical changes to habitat conditions), forestry and urban wastewater.



All waterbodies require further action or measures. Some waterbodies require either

- **Measures to ensure they are protected** and do not deteriorate.
- More **robust restoration measures** to achieve at least good status.
- Require **further assessment** to determine what the next steps are in terms of implementing measures.

Where a waterbody has an At risk status, **restoration measures** addressing the significant pressures outlined above will be required to ensure that it achieves its environmental objectives.

Measures to protect 1,983 Not at Risk waterbody from deteriorating are also required.

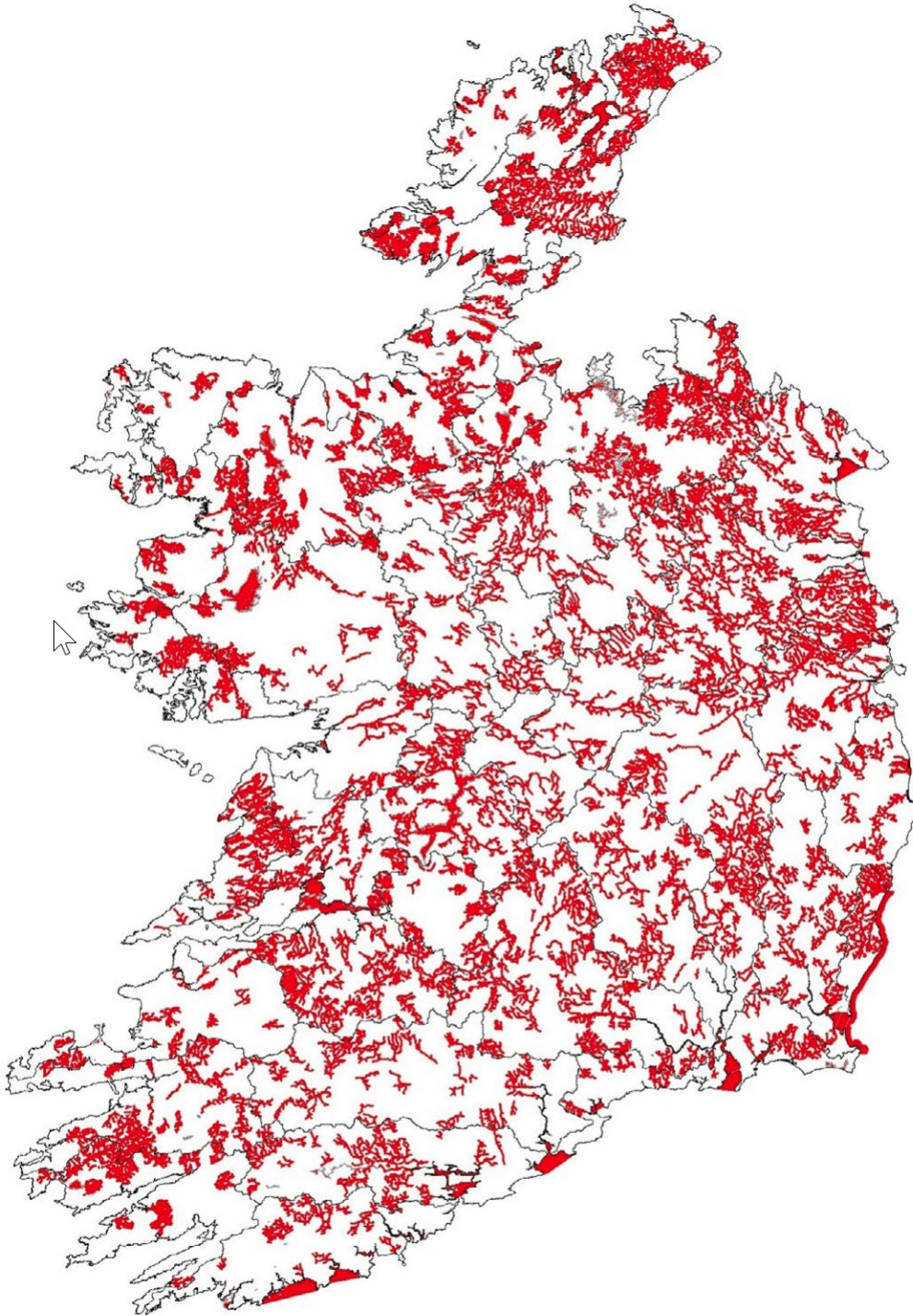
The 1,256 waterbodies with **review status** require further assessment. There are two components to review status waterbodies in terms of action and measures as follows:

- In approximately 25% of waterbodies in review, measures are in place, but the water quality improvement has not yet been realised, or there has been some slight indication of progress but not enough yet to categorise them as Not at Risk. Therefore, these waterbodies require further monitoring and assessment and this action is already accounted for in the EPA monitoring programme.
- In the remaining 75% of waterbodies in review, there is currently inadequate evidence to determine whether or not the water body is At risk. Measures should be implemented to ensure this additional evidence can be obtained.

Waterbody Type	Type of measures required				Total
	Protect	Additional Evidence Required	Measures Assessment Required	Restoration	
River	1,143	568	171	1,310	3,192
Canal	6	-	8	2	16
Lake	402	256	15	139	812
Transitional	42	84	18	52	196
Coastal	55	41	4	12	112
Groundwater	335	-	91	88	514
Total	1,983	949	307	1603	4,842




Central to the approach is targeting the measures where they are most needed, *i.e.*, areas at risk. It will ensure that the resources and actions will focus on the areas of the country where water quality is most at risk. As noted above, there is evidence for the second RBMP that focused measures in priority areas for action resulted in more significant water quality improvements.

The map below shows the waterbodies identified as being at risk.



0 15 30 60 Km

Data Source: EPA / OSi
Date: 31/03/2021
EPA Catchments Unit

-  Catchment Boundaries
-  At Risk River Waterbodies
-  At Risk Lakes, Transitional and Coastal Waterbodies



Comhairle Chontae Liatroma
Leitrim County Council



Leitrim Heritage
Oidhreacht Liatroma

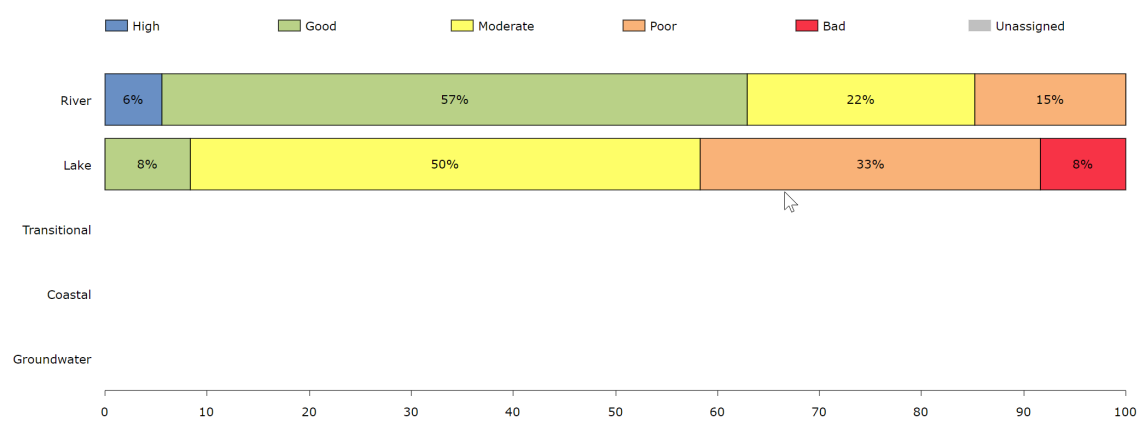


An Roinn Tithíochta,
Rialtas Áitiúil agus Oidhreacht
Department of Housing,
Local Government and Heritage

Water Quality in Leitrim

Sixty-three per cent (63%) of Leitrim's monitored rivers (SW 2013- 2018) are classed as high or good, with 22% classed as moderate and the remaining 15% as poor. The status of Leitrim's rivers is better than river status nationally, with 52%, 28% and 19% classified as high and good, moderate, and poor, respectively.

The (SW2013-2018) status of Leitrim's, monitored lakes showed 8% of lakes' good quality, 50% moderate, 33% poor, and 8% bad.

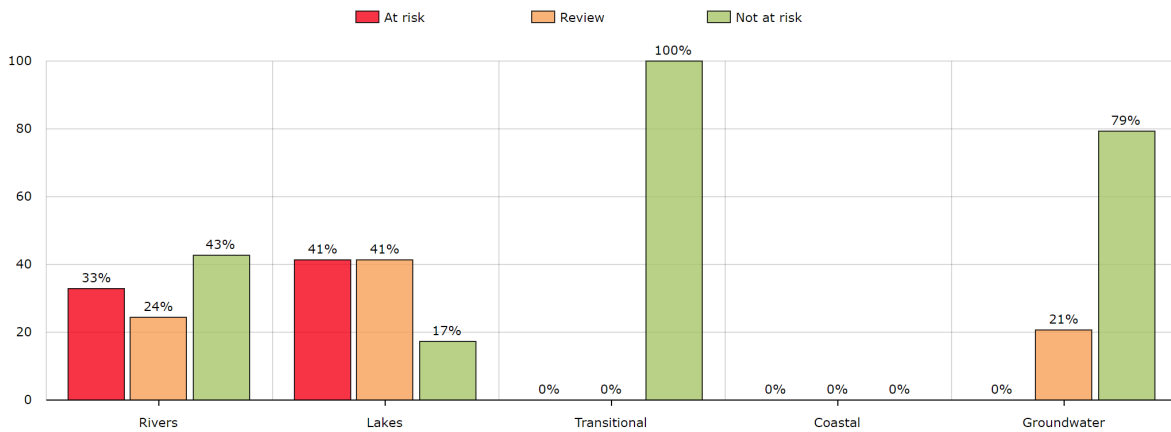


Status of Irish Waters	High	Good	Moderate	Poor	Bad	Unassigned
River	6%	57%	22%	15%	0%	0%
Lake	0%	8%	50%	33%	8%	0%
Transitional	0%	0%	0%	0%	0%	0%
Coastal	0%	0%	0%	0%	0%	0%
Groundwater	0%	0%	0%	0%	0%	0%

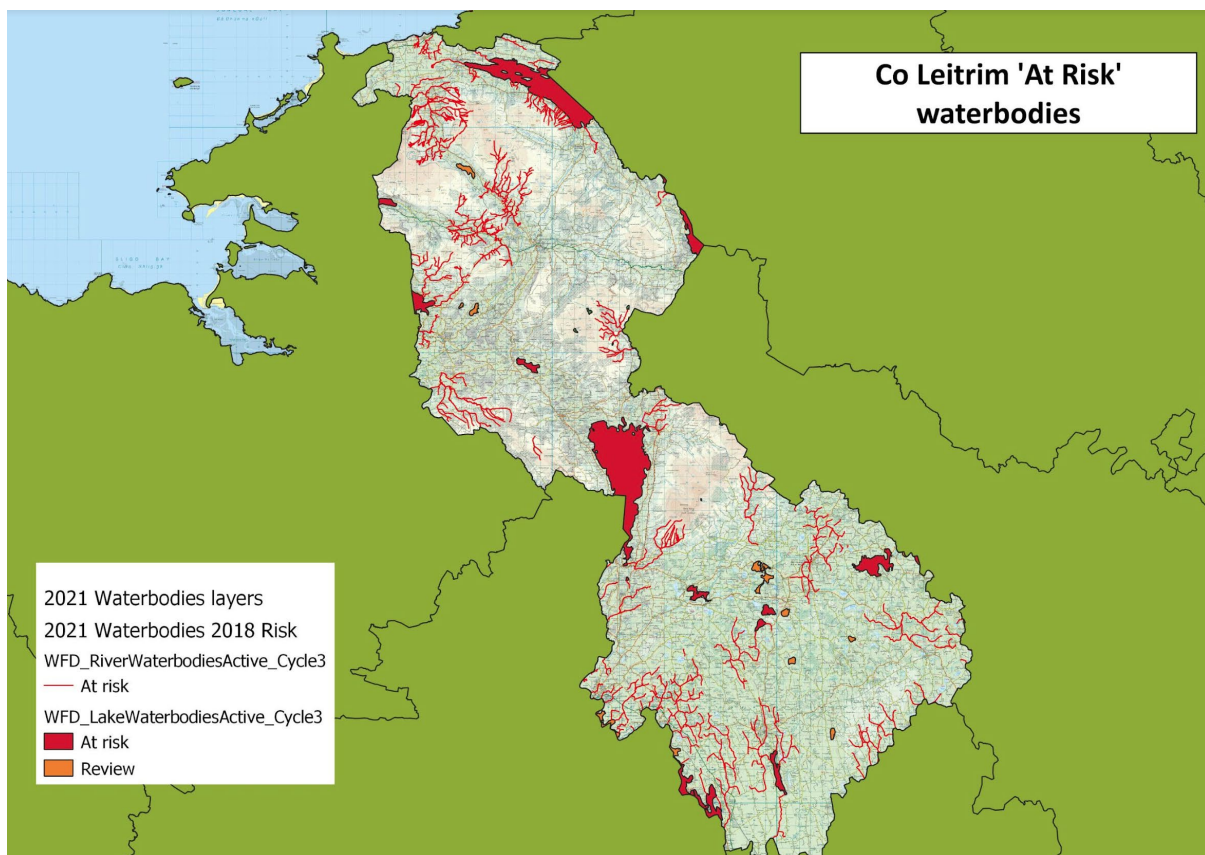
It compares favourably with the national status of Irish lakes of high, good, moderate, poor, and bad of 8%, 43%, 32%, 13%, and 5%, respectively.

The temporal trend in the status of all Leitrim water bodies shows an almost 50% decrease in high-status water bodies from 10% down to 5%.

In WFD cycle 2, 33% of rivers and 41% of lakes were classed as **At risk**. Twenty-four per cent (24%) and 41% of rivers and lakes, respectively, were **under review**. Twenty-one per cent of groundwater were under review



The location of the rivers and lakes classified as being at risk are shown in the map below.

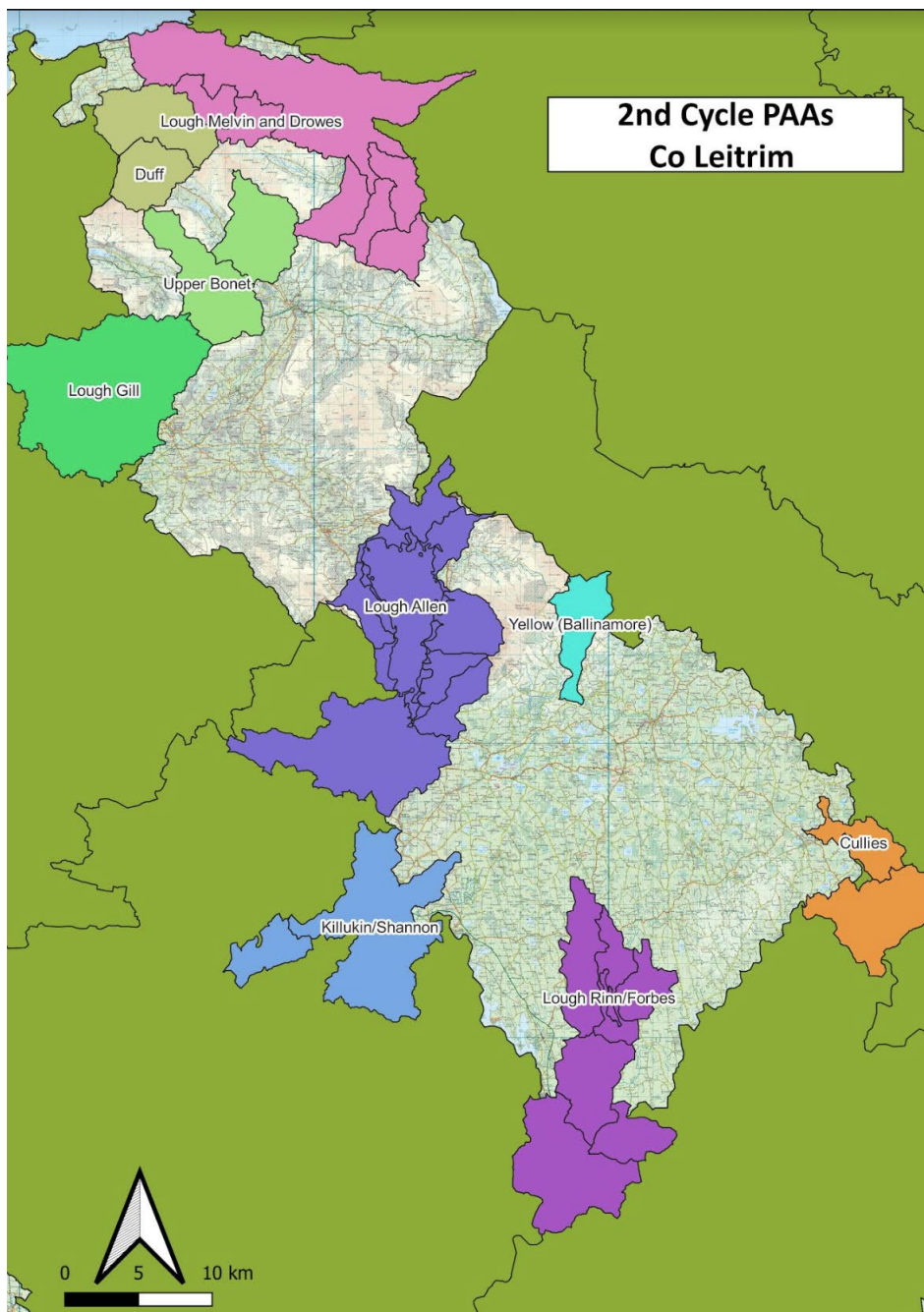


The **At-Risk** status refers to waterbodies not meeting the WFD objective, *i.e.*, Good status. It is extended into the 3rd RBMP cycle for two categories:

- Waterbodies for 'Restoration'
- Waterbodies for Protection (Protect), *i.e.*, keep their High status - especially Blue Dot rivers.

The Blue Dot Programme⁴³ is a collaborative programme delivered by various agencies to focus attention and resources towards protecting and restoring our declining stock of pristine high-status objective waters. The programme endeavours to raise awareness amongst land managers and state bodies on the sensitivity of these waters.

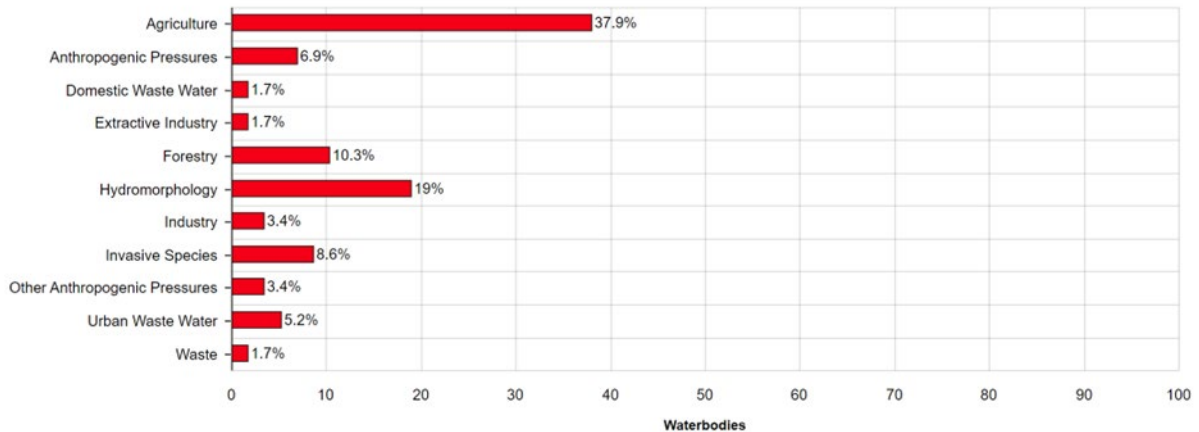
In Leitrim, the draft RBMP has identified several areas for action. These were called Priority Areas for Action in the second cycle.



⁴³ <https://lawaters.ie/blue-dot-programme/>

In these areas, agriculture was identified as a significant pressure, 38%, followed by hydromorphology⁴⁴ at 19% and forestry at 10%.

Significant Pressures Impacting At Risk Waterbodies



Leitrim's high-status objective waterbodies are shown in the table below.

Water Quality Status - High Status Objective Waterbodies

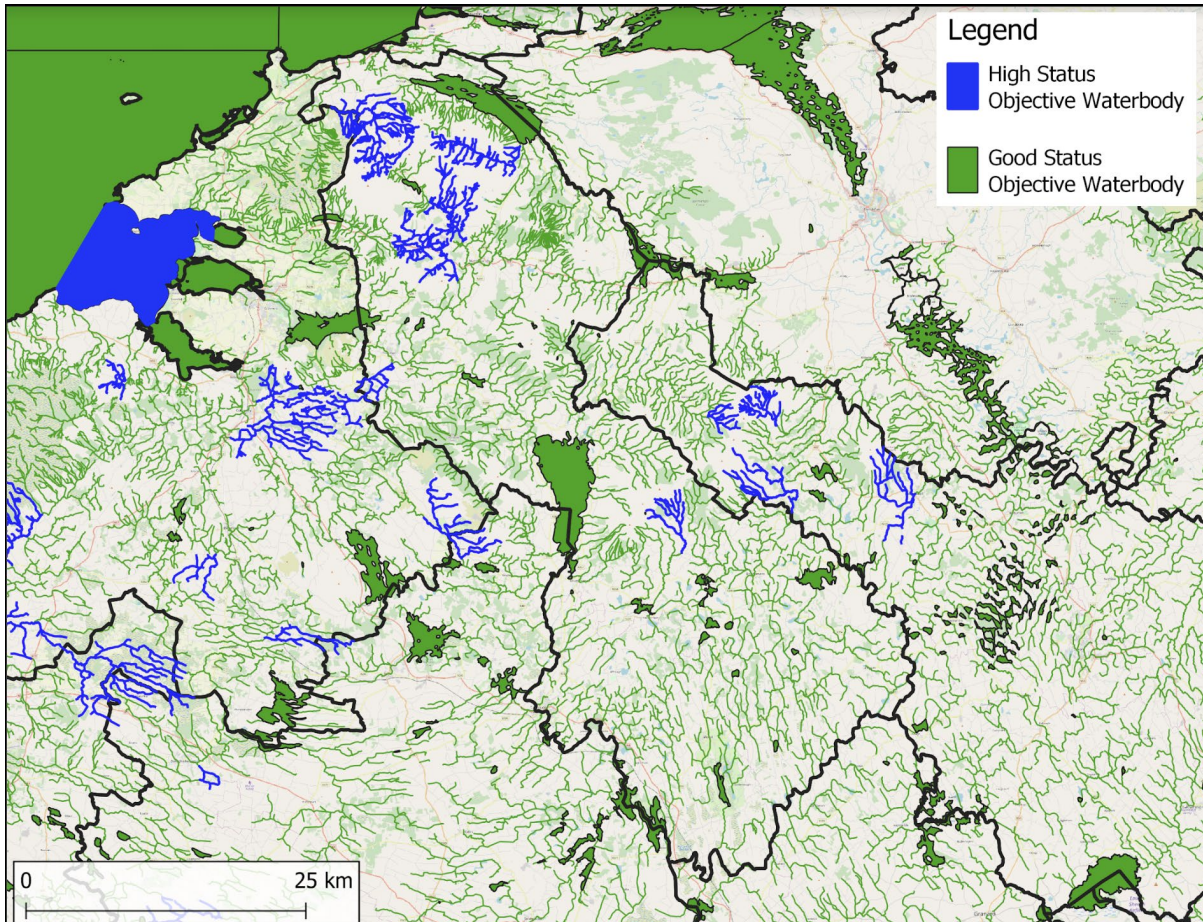
SCALE: Catchment Local Authority

SELECT TYPE:

	SW 2007-2009	SW 2010-2012	SW 2010-2015	SW 2013-2018
AGHACASHLAUN_010 (River)	High	High	High	Good
BONET_020 (River)	High	High	Good	High
DUFF_010 (River)	High	High	Good	Good
DUFF_020 (River)	High	High	Good	High
GLENANIFF_010 (River)	High	High	High	Good
SHANVAUS_010 (River)	High	High	Good	Good

⁴⁴ Hydromorphology considers the physical character and water content of water bodies. Good hydromorphological conditions support aquatic ecosystems. Pressures can include abstraction, impoundment (i.e. dams and weirs), channelisation and embankments.

They are included in the Blue Dot programme. Farmers must know if their land is one of these areas because it takes very little contamination to move into a lower status. These lands are included in the Breifni ACRES Cooperation Project zones.



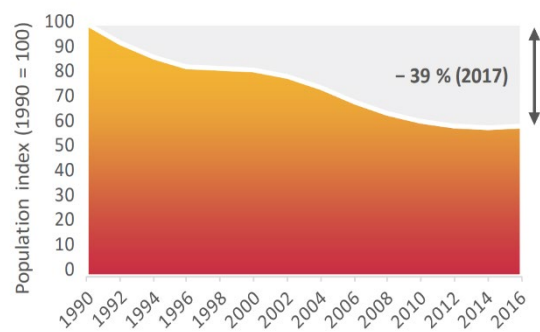
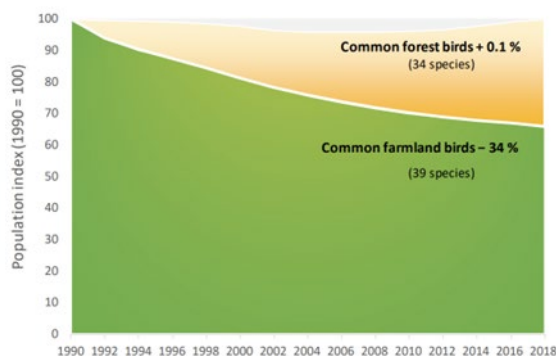
8. BIODIVERSITY

Introduction

Biodiversity refers to the number, variety, and variability of living organisms, from microscopic organisms to higher plants and animals. Collectively, they contribute to the delivery or regulating the delivery of ecosystem services. Biodiversity plays a crucial role in ecosystem stability and a measure of a system's resilience to environmental change, as expected from future climate shifts. However, there are increasing global trends associated with biodiversity decline, for example.

- Biodiversity⁴⁵ experts estimated that about 30% (uncertainty range: 16–50%) of species have been globally threatened or driven to extinction since the year 1500.
- There is an overwhelming consensus that global biodiversity loss will likely decrease ecosystem functioning and nature's contributions to people.
- Global biodiversity loss and its impacts may be more significant as our knowledge grows.
- Experts estimated that significantly increasing conservation investments and efforts now could remove the threat of extinction for one in three species that may otherwise be threatened or extinct by the year 2100.

Agricultural intensification, in recent times, has been associated with biodiversity loss. This loss of biodiversity from farmed land is often perceived as declining wildlife such as plants, insects, mammals and birds. However, the loss of living organisms at the microscopic level is equally important to delivering ecosystem services. Birds and butterflies are considered good indicators of farmland biodiversity changes. The EU Farmland Bird Index shows a 34% decline in farmland birds (left) and



butterflies (right)⁴⁶ over the last 30 years.

European trends of biodiversity loss are reflected

- Research has shown that more than half of Ireland's bee species have declined substantially since 1980, with 30% of species considered threatened with extinction⁴⁷.

⁴⁵ <https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/fee.2536>

⁴⁶ https://www.arc2020.eu/wp-content/uploads/2020/06/SR_Biodiversity_on_farmland_EN.pdf

⁴⁷ <https://www.nature.com/articles/nature05764>

- Many people are now noticing the general lack of insects in their surroundings. If insect species and population declines continue, we will lose the vital ecological functions performed by these small but mighty allies, such as pollination, decomposition and food for other wildlife.
- The latest review of Birds of Conservation Concern from BirdWatch Ireland states that a staggering 63% of species, including previously common birds such as House Sparrows and Starlings, are declining at alarming rates⁴⁸ (Gilbert et al., 2021).
- Despite ongoing conservation and restoration efforts, Ireland's biodiversity is in a state of crisis, and urgent, impactful action is imperative to prevent the continued erosion of our natural capital⁴⁹.

Farmed land is Ireland's most relevant land use for biodiversity and all our natural capital.

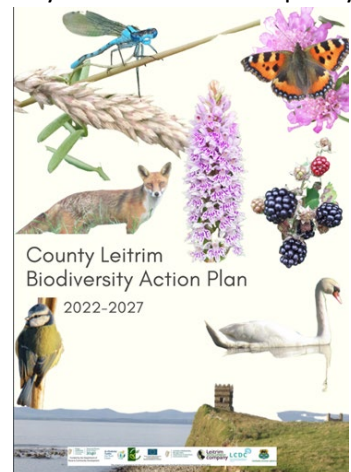
Ireland has an estimated 6.9 m ha of land, of which about **64%**, or 4.44 m ha, is used for agriculture. In Leitrim, it is 57% reflecting the large areas covered by 21 lakes and uplands.

Land use and management intensity are key factors influencing biodiversity in farming systems as it reduces food and habitat availability for wildlife. The management of Irish grassland using high fertiliser inputs and stocking rates has resulted in monocultures of perennial ryegrass on many intensive grazing livestock farms. These intensively grazed areas are associated with free-draining soils and climatic conditions favouring long grass-growing seasons. It has resulted in the loss of species above and below ground due to reductions in habitat variety.

However, land use is also involved in biodiversity loss in our water resources. As noted in the water section of this report, about half of our rivers and lakes are in an unhealthy ecological state. The number of pristine river sites has dropped from 500 to 20 over the past 40 years. These water quality declines have major consequences for many freshwater species, such as the freshwater pearl mussel, Ireland's longest-living animal, which is under threat owing to water quality issues and river flow and hydrology changes.

Leitrim's biodiversity

The County Leitrim Biodiversity Action Plan 2022-2027⁵⁰ describes the County's diversity of habitats, including peatland, wetland, woodland, grassland and coastal habitats. The County has eight Special Areas of Conservation and Special Protection Areas (for Peregrine Falcon and



⁴⁸ <https://www.southwexfordcoast.com/swcprom/wp-content/uploads/2021/05/BOCCI-Version-4.pdf>

⁴⁹ [https://www.gov.ie/en/consultation/1566c-public-consultation-on-irelands-4th-national-biodiversity-action-plan/?referrer=http://www.gov.ie/biodiversityplan/#:~:text=Ireland's%204th%20National%20Biodiversity%20Action%20Plan%20\(NBAP\)%20has%20been%20in,we%20value%20and%20protect%20nature.](https://www.gov.ie/en/consultation/1566c-public-consultation-on-irelands-4th-national-biodiversity-action-plan/?referrer=http://www.gov.ie/biodiversityplan/#:~:text=Ireland's%204th%20National%20Biodiversity%20Action%20Plan%20(NBAP)%20has%20been%20in,we%20value%20and%20protect%20nature.)

⁵⁰ http://www.ldco.ie/assets/uploads/Website_Final_Leitrim_Biodiversity_Plan_2022-2027.pdf

Chough). Collectively, these sites are known as Natura 2000 sites and cover an area of 18,500 ha or just under 12% of the County's land area.

There are nine National heritage areas in Leitrim, adding 5,300 ha designated for nature protection.

There are an additional 28 proposed natural heritage areas. These are areas of significance for wildlife or habitats.

Wetland sites in Leitrim support rich biodiversity - including many rare flora species, invertebrates, bird life and otter. Woodlands and hedgerows support iconic species such as Badger, Pine Marten, Hedgehog and Birds of Prey.

Rivers, streams and hedgerows are essential ecological corridors that traverse the landscape. They provide habitats locally and are crucial to maintaining links between large habitat areas and wildlife populations, reducing the impact of habitat loss and fragmentation.

The value of woodlands, in general, is increased where they are connected by good hedgerow networks across the landscape, allowing species movement between sites. Small wetland sites, woodlands, semi-natural grasslands and even wildlife-friendly parks and gardens provide important steppingstone habitats facilitating the movement of species across the landscape.

High nature value (HNV) farmland in Ireland covers approximately 33% of the agricultural land, and 50% of these areas coincide with Natura 2000 land. Irish landscapes are dominated by semi-natural vegetation from upland areas to lowland areas⁵¹.

County Leitrim has a rich and diverse natural heritage. The County is not immune to biodiversity loss, with habitats and the species they support being threatened. The pressures on the County's biodiversity include coniferous afforestation, intensive farming practices, waterbody degradation, the spread of invasive species and climate change.

The County Leitrim Biodiversity Action Plan aims to raise awareness of biodiversity amongst individuals and communities in County Leitrim by providing support, guidance and encouragement to engage with biodiversity through education and practical conservation participation.

Four common biodiversity elements of Leitrim highly relevant to farming are shown in the figure below, and some relevant summary information on each is provided.

⁵¹ <https://www.ecologyandsociety.org/vol26/iss1/art20/>



Hedgerows⁵²

Hedgerows provide a range of ecosystem services on farms provide a range of benefits and ecosystem services.

- **Water quality** – hedgerows trap silt and soil particles, which clog up fish spawning grounds if they enter watercourses
- **Cultural / Historical** – hedgerows are part of Ireland's cultural, historical and archaeological heritage. Townland boundary hedgerows are particularly important
- **Wildlife** - as the area of native woodlands in Ireland is small, hedgerows have become vital wildlife habitats
- **Landscape** – hedgerows give a particular landscape character and a sense of place. They provide an identity to a townland or County, making it distinct from other areas.
- **Shelter** - hedgerows provide protection for livestock and crops for up to thirty times their height. A dense base is also more effective
- **Scenic appearance** - Characteristic Irish hedgerow enhance the countryside

They also provide habitats for wildlife:

- **Hedgerow trees** – Mature trees offer roosts to bats, while saplings just above the height of the hedgerow are necessary perching posts for birds
- **Birds** – Of the 110 species regularly recorded in the Countryside Bird Survey in Ireland during the breeding season, 55 use hedgerows. Of these, 35 nests in hedgerows over 1.4 m high and 1.2 m wide provide cover from overhead and ground predators.

⁵² <https://www.teagasc.ie/environment/biodiversity--countryside/farmland-habitats/value-of-hedgerows/>

- **Cover** – Hedgerows with a dense base provide cover for small birds and mammals, such as the hedgehog. The barn owl hunts along hedgerows for prey, such as the field mouse
- **Places for Plants** – Hedgerows provide homes for many native flora, such as the primrose. Flora, in turn, provides food sources, such as blackberries on the bramble

Hedgerows can also sequester carbon⁵³. Preliminary estimates suggest that hedgerow and non-forest woodlands could potentially sequester 0.66–3.3 t CO₂/ha/year.

The hedgerow network in County Leitrim is of relatively recent origin⁵⁴. A survey of hedgerows in Leitrim was published in 2006 by Niall Foulkes. The total length of hedgerows in County Leitrim was estimated at 11, 609 km, and the average figure for hedgerow density was 7.31 km per square km.

The hedgerow landscape in County Leitrim is varied. There is a mixture of farmland with clearly defined field boundaries and other areas with irregular, scrub-like borders, which tax the definition of 'hedgerow' to the limit.

Leitrim recorded the highest proportion (47%) of species-rich hedges. Four species dominate the County's hedgerows Whitethorn (present in 99% of hedges), Blackthorn, Ash and Holly. Holly, along with Willow, Alder and Rowan, occur frequently.

Leitrim's hedgerows show more linkage with other natural and semi-natural habitats. The County's extensive farming leaves a high proportion of the land agriculturally unimproved. It has positive implications for biodiversity in the area.

Watercourses

A watercourse is any natural or artificial channel above or below ground through which water flows, such as a river, stream, ditch, mill stream or culvert. Watercourses are valuable assets that provide us with vital water supplies, support our natural habitats and biodiversity, and contribute in no small way to our agricultural, fishery and tourism sectors⁵⁵.

High Nature Value Grassland

High Nature Value Grassland (HNV) farmland in Ireland covers a broad range of landscape types dominated by semi-natural vegetation (from upland to lowland areas). It broadly reflects the natural constraints on land use intensification. HNV farmland is characterised by a combination of low-intensity land use, the presence of semi-natural vegetation and landscape mosaics. It is essential for biodiversity and represents a resource critical to developing ecosystem services.

COUNTY LEITRIM HEDGEROW SURVEY REPORT

N. Foulkes

5th November 2006

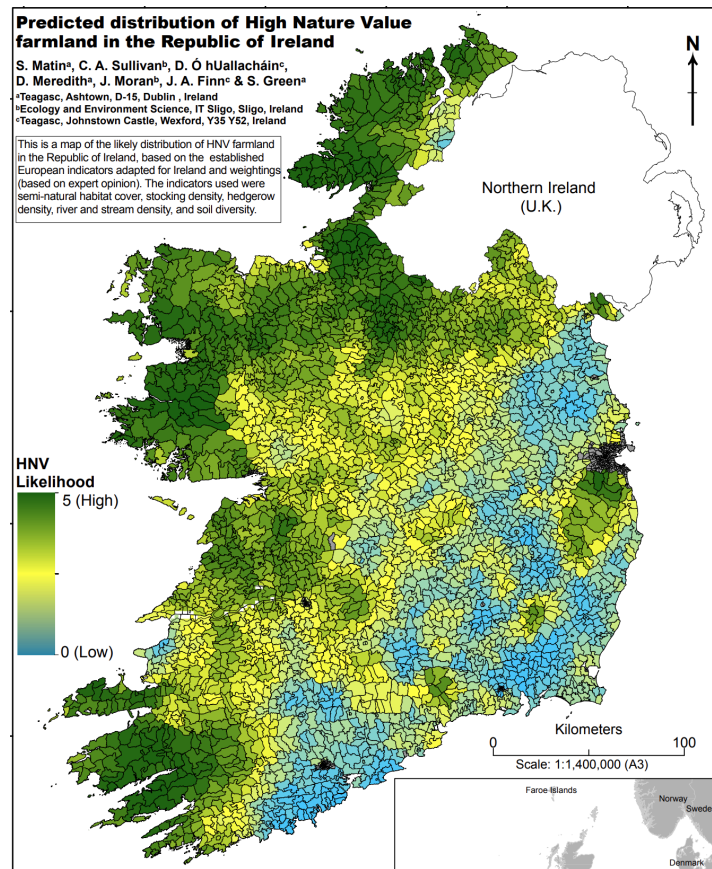
This project was funded by the Heritage Council under the
Wildlife Grant Scheme 2006

⁵³ <https://www.epa.ie/publications/research/climate-change/ccrp-32-for-webFINAL.pdf>

⁵⁴ <https://hedgelaying.ie/wp-content/uploads/2019/11/County-Leitrim-Hedgerow-Survey-Report.pdf>

⁵⁵ <https://flooding.ie/wp-content/uploads/2020/01/riparian-guide-january-2020.pdf>

A recent study, using indicators, mapped the likelihood of the occurrence of HNV farmland in Ireland⁵⁶.



The map clearly shows Leitrim has a high potential for HNV grasslands. It reflects Leitrim's high semi-natural habitat cover, low stocking density, high hedgerow and river and stream density and soil diversity.

It is interesting to note that some of the research that led to the inclusion of results-based payments in the new ACRES cooperation projects was conducted by Dr Dolores Byrne, Atlantic Technical University^{57,58}.

Species Rich Grasslands.

The practical preservation of HNV is crucial for Leitrim's biodiversity. There is a range of Irish HNV grassland types⁵⁹.

- **Wet grassland:** This can be a common and extensive semi-natural grassland type in Ireland. They typically contain rushes. If orchids are present, they indicate low soil fertility and low-intensity management history. Birds such as curlew, which are suffering significant declines in population, may nest in these grasslands

⁵⁶ <https://t-stor.teagasc.ie/handle/11019/1658>

⁵⁷ <https://rbaps.eu/pilot-areas/rbaps-measures-in-ireland/leitrim/>

⁵⁸ <https://www.ecologyandsociety.org/vol26/iss1/art20/>

⁵⁹ <https://www.farmingfornature.ie/resources/best-practice-guides/managing-species-rich-grasslands/>

- **Calcareous grassland:** This is dry grassland found in areas with limestone geology (like The Burren), can be exceptionally flower-rich, and are an excellent habitat for orchids.
- **Molinia grassland:** This is a less common type of wet grassland. It supports a wide range of flowers, some purple moor grass ('Molinia'), and when well-managed, can attract the rare marsh fritillary butterfly that relies on the purple-flowered devil's bit scabious.
- **Hay meadow:** These grassland areas can be wet or dry, but are managed by mowing, typically one late summer cut. It is now a scarce habitat. When in full bloom there are dog daisies, common knapweed, yellow rattle, vetches, yarrow and many more – a wide variety of species and colours.
- **Acid grassland:** Generally found in acidic upland areas, they support mat grass, sheep's fescue and sedges, whilst mosses and liverworts can be abundant too.

These grasslands provide a range of farming, ecological, and cultural benefits.

Peatland⁶⁰

Peatlands result from the steady accumulation of undecomposed dead plant material in bogs or fens. There is no single definition for peatland, but ecologists use a minimum depth of 30 cm.

Given the broad dominance of peat-rich soils throughout Leitrim – particularly in the north of the County- they play a key part in delivering a wide range of ecosystem services at the landscape scale, particularly carbon storage and water supply. However, it will only be achieved if the peat bog habitat is correctly identified, characterised and managed appropriately. If this can be achieved, these peat-dominated landscapes can help underpin a sustainable rural community and provide key benefits to society (*e.g.*, water supplies, carbon storage and sequestration) as a whole.

⁶⁰ <https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2019-07/1%20Definitions%20final%20-%205th%20November%202014.pdf>

In summary

- Increasing biodiversity, particularly wildlife populations, can benefit farmers by improving agricultural productivity.
- Biodiversity is important for regulating ecosystem processes and delivering ecosystem services.
- Farming approaches can be tailored to benefit wildlife and biodiversity, increasing ecosystem stability in the face of environmental change.

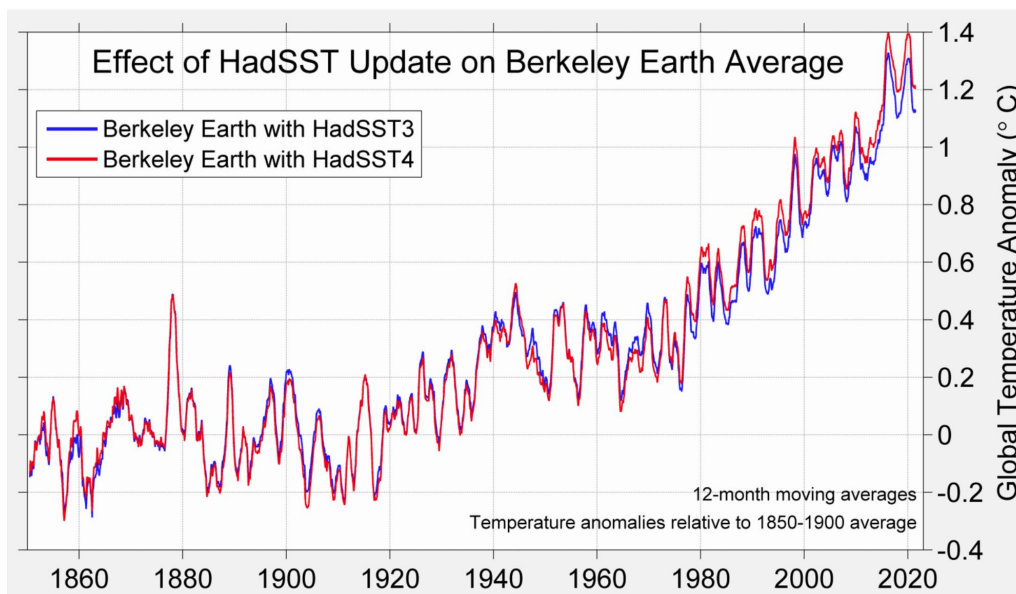
9. CLIMATE CHANGE AND MITIGATION

World temperatures are rising because of human activity, and climate change now threatens every aspect of human life. If left unchecked, humans and nature will experience catastrophic warming, with worsening droughts, greater sea level rise and mass extinction of species. There are enormous challenges, but there are potential solutions.

Climate is the average weather in a place over many years. Climate change is a shift in those average conditions. The rapid climate change we are now seeing is caused by humans using oil, gas and coal for their homes, factories and transport. When these fossil fuels burn, they release greenhouse gases (GHG), mainly carbon dioxide. These gases trap the sun's heat and cause the planet's temperature to rise.

Farming releases significant amounts of methane and nitrous oxide, two potent GHGs. Methane is produced by livestock during digestion due to enteric fermentation. It can also escape from stored manure. Nitrous oxide emissions are an indirect product of organic and mineral nitrogen fertilisers applied to land.

The world is about 1.2° C warmer than it was in the 19th century, as shown in the graph below⁶¹.



Scientists say that temperature rises must slow down and not exceed 1.5° C by 2100 to avoid damaging consequences. If nothing is done, temperature rises could exceed 4° C resulting in devastating heatwaves, millions losing their homes to rising sea levels and irreversible loss of plant and animal species.

Extreme weather events are already more intense, threatening lives and livelihoods. Warming will turn farmland in some world regions into deserts, while extreme rainfall in others will cause historic flooding.

⁶¹ <http://berkeleyearth.org/global-temperature-report-for-2021/>

Climate change is already devastatingly impacting our economy, society and environment and will continue to do so into the future⁶². In Ireland, we are already experiencing the results of this through flooding, more extreme weather and rising sea levels. As the threats from climate change increase, so does the need for urgent action to address them.

The key findings of Ireland's Provisional GHG 1990-2021⁶³ report by the EPA were summarised as follows:

Increase in overall GHG emissions driven by coal fired electricity	2021 total national greenhouse gas emissions are estimated to have increased by 4.7% on 2020 levels to 61.53 million tonnes carbon dioxide equivalent (Mt CO ₂ eq). This increase in total emissions was driven by increased use of coal and oil for electricity generation and increases in both the Agriculture and Transport sectors. It highlights that further, transformative measures will be needed to meet National Climate ambitions.
EU Effort Sharing limits exceeded	The provisional estimates of greenhouse gas emissions indicate that Ireland will exceed its 2021 annual limit, without the use of flexibilities, set under the EU's Effort Sharing Regulation (ESR) by 2.71 Mt CO ₂ eq. This is the first year of compliance under the ESR.
Higher 2021 emissions both within and outside the Emissions Trading Scheme	Emissions from Ireland's Emissions Trading Sector (ETS) increased by 15.2% or 2.02 Mt CO ₂ eq in 2021 while ESR emissions increased by 1.6% or 0.73 Mt CO ₂ eq.
Carbon Budget 2021-2025	Provisional National total emissions (including LULUCF) for 2021 at 69.29 Mt CO ₂ eq have used 23.5% of the 295 Mt CO ₂ eq Carbon Budget for the five-year period 2021-2025. This leaves 76.5% of the budget available for the succeeding four years, requiring an 8.4 per cent average annual emissions reduction from 2022-2025 to stay within budget.
More coal and less wind means more emissions from electricity generation	Emissions in the Energy Industries sector increased by 17.6% or 1.53 Mt CO ₂ eq in 2021. This is attributable to a tripling of coal and oil use in electricity generation as gas fired plant were offline. Electricity generated from wind and hydro decreased by 16% and 20% respectively in 2021. Emissions intensity of power generation increased from 296g CO ₂ /kWh in 2020 to 331g CO ₂ /kWh in 2021.
More livestock and fertiliser use increase Agriculture emissions	Agriculture emissions increased by 3.0% or 0.67 Mt CO ₂ eq in 2021, driven by increased fertiliser nitrogen use (5.2%), limestone application (49.5%) increased numbers of livestock including dairy cows (2.8%), other cattle (0.3%), sheep (0.3%) and pigs (4.5%). Total milk production increased by 5.5% in 2021, with milk output per cow also increasing (2.5%).
Transport emissions increase post COVID	Greenhouse gas emissions from the Transport sector increased by 6.1% or 0.63 Mt CO ₂ eq in 2021. This increase was largely driven by ending COVID travel restrictions on passenger car and public transport usage. By the end of 2021 there were 47,000 electric vehicles in Ireland, ahead of the Climate Action Plan trajectory. International aviation, not included in national total emissions, also increased by 11.6% in 2021 or by 0.14 Mt CO ₂ eq.
Residential emissions decrease	Greenhouse gas emissions from the Residential sector decreased by 4.9% or 0.36 Mt CO ₂ eq, driven by a combination of: reduced time in the home due to ending COVID restrictions, a milder winter, increased fuel prices and a possible stockpiling of heating oil from 2020. Coal, peat and kerosene sales declined by 4.6%, 5.0% and 11.8% whilst natural gas showed an increase of 0.9%.

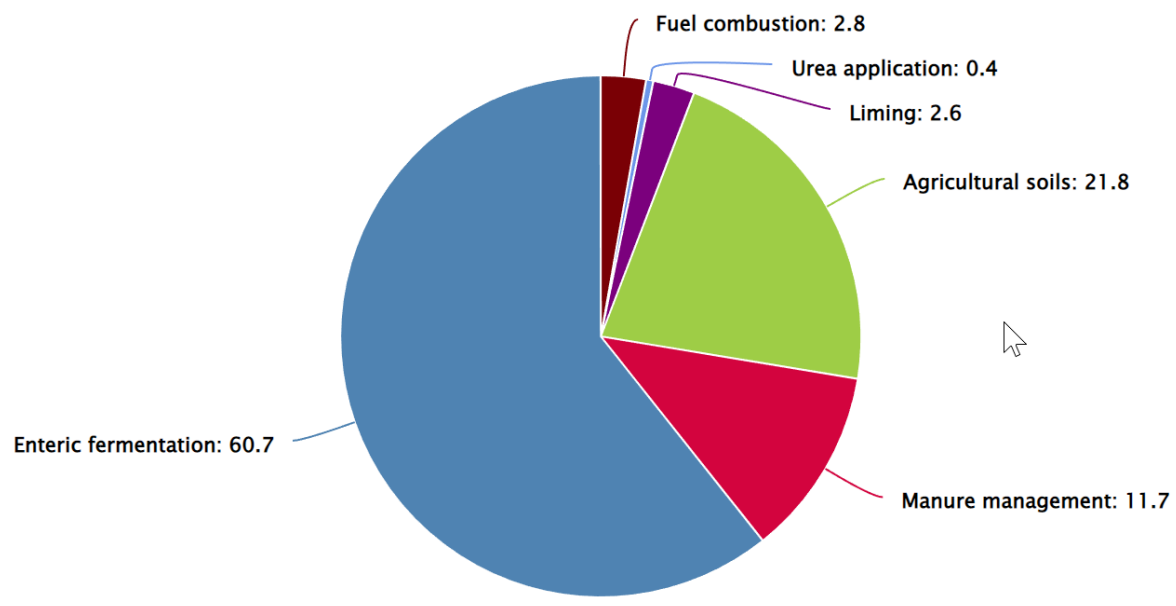
⁶² <https://www.gov.ie/en/policy/d7a12b-climate-action-and-environment/>

⁶³ https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/EPA-Ireland's-Provisional-GHG-Emissions-1990-2021_July-2022v3.pdf

Climate Change and Agriculture

Climate change is challenging for Irish agriculture, both in the context of GHG emissions and the need to adapt farming practices to be more resilient to the impacts of climate change⁶⁴.

The Irish agriculture sector was responsible for 37.5% of Irish GHGs emissions in 2021.



Teagasc identified four significant impacts of climate change on agriculture⁶⁵

Impact	Risk
Wetter winters	More intense storms and rainfall, increased likelihood and magnitude of river and coastal flooding
Drier summers	Water shortages in summer, heat stress for animals
More frequent extreme weather events	Such as storms and droughts. Risk of fodder shortages, risk of damage to infrastructure
Increased risk of new pests and diseases of animals and plants	This may make it impractical to grow certain crops because of an increase some diseases and parasites

Leitrim farmers take great pride in how they look after the environment they live in and farm⁶⁶. Leitrim farmers are generally aware of their responsibilities to their families, future generations of farmers and the local communities to minimise their environmental impact. It is evidenced in the other sections of this report and the consortium's activities around the four project objectives. While much work has been done and is continuing, there is a need to review Leitrim's gaseous emissions and explore mitigation options.

⁶⁴ <https://www.epa.ie/our-services/monitoring--assessment/climate-change/ghg/agriculture/>
⁶⁵ <https://www.teagasc.ie/environment/climate-change--air-quality/signpost-programme/publications-/why-engage-with-climate-action/>
⁶⁶ Thinking Differently – Aiden Wryne <https://youtu.be/43lw8OnvIE4>; Leaving something better behind – James Gilmartin https://youtu.be/1_nmLaMCRZc

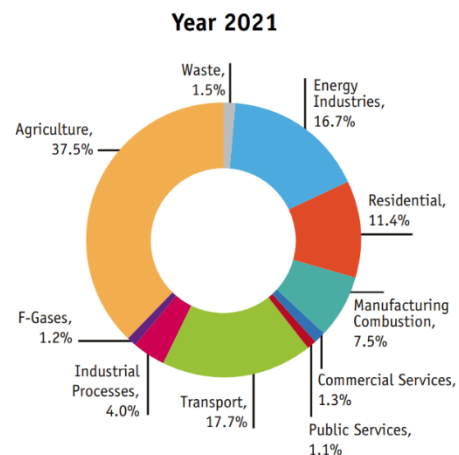
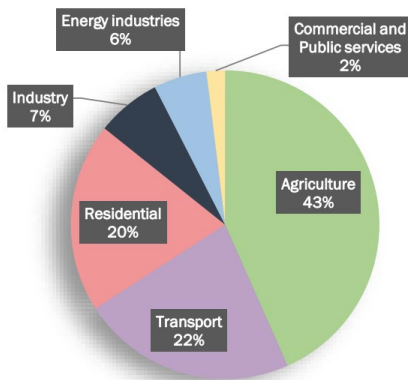
Greenhouse Gas Inventory for Leitrim

The milestone research work by Good Energies Alliance Ireland (GEAI) Erasmus + researchers, with the advice of academics and local experts, is the first Irish county GHG inventory⁶⁷. The report provides a GHG emission baseline for 2019.



The report identifies six sectors as emitters of GHGs. These are:

- Transport (22% of total)
- Energy Industries (6% of total)
- Residential (20% of total)
- Industry (7% of total)
- Commercial and Public Services (2%)
- Agriculture (43%)



The national results⁶⁸ show that agriculture GHG emissions account for 37.5% of the total, while the agriculture emissions in Leitrim account for 43% of the total. The higher agricultural contribution in Leitrim reflects the lower population, therefore lower transport and residential emissions, and industry compared with the national situation.

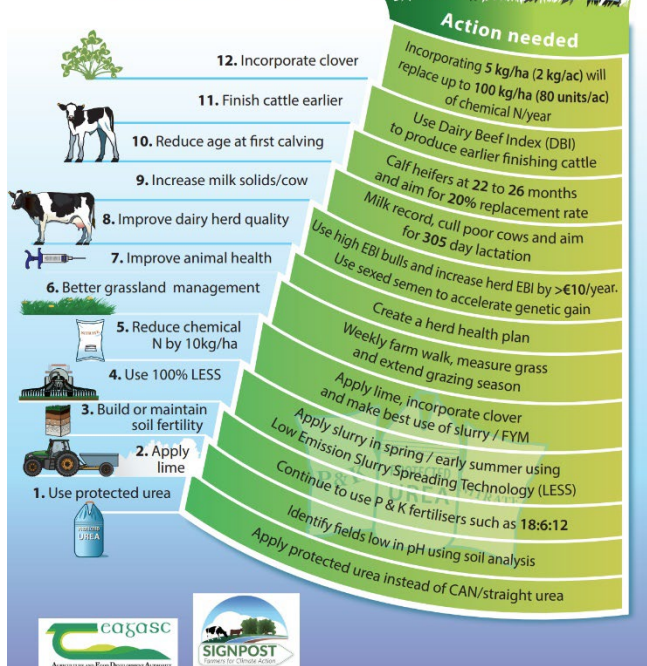
The GEAI report estimated agriculture emissions of 188,518 tonnes representing 1% of the national total (61.53 million tonnes of carbon dioxide equivalent in 2021⁶⁹).

⁶⁷ https://www.goodenergiesalliance.ie/wp-content/uploads/2019/12/Cr%C3%B3ga_baseline-GHG-inventory_report_GEAI_December-2019.pdf

⁶⁸ <https://www.epa.ie/our-services/monitoring--assessment/climate-change/ghg/>

⁶⁹ <https://www.epa.ie/our-services/monitoring--assessment/climate-change/ghg/latest-emissions-data/>

Where are you on the 12 Steps to reduce Gaseous Emissions on YOUR FARM?



Leitrim's agricultural GHG emissions per ha are almost half the national average. It reflects the lower farming intensity associated with Leitrim's soils and smaller farm sizes.

In terms of mitigation options, Teagasc is focusing on intensive farming systems (see the panel below). This approach is understandable, as these systems will be associated with the highest emissions. However, the applicability of the mitigation measures to Leitrim's extensive farming systems needs further consideration.

In 2019, Climate Change Advisory Council report ⁷⁰ identified various mitigation options. They included:

- They note that a reduction of suckler cow numbers must be facilitated by long-term and consistent support for stable incomes to provide favourable environmental outcomes through land management (*i.e.*, Carbon Farming – See

below).

- Management options for wetlands, especially peatlands, require urgent assessment and implementation (see below). Peatland's potential to sequester carbon and offset emissions is particularly relevant to Leitrim.
- The drainage of peat for multiple land uses, including peat extraction, must cease. Areas for rewetting should be identified, and associated land management programmes should be started. However, time is of the essence, as peatland ecosystems will take several years to re-establish and build resilience to projected climate changes.
- Adoption and successful implementation of climate change mitigation policy and measures depends on farmers' acceptance based on their lived experience, knowledge and understanding. Additional research and resources to enable effective knowledge exchange are required.
- Noting the success of participatory approaches to engagement – such as the European Innovation Partnership projects⁷¹ a process of co-design could be implemented to facilitate

⁷⁰

<https://www.climatecouncil.ie/media/climatechangeadvisorycouncil/Working%20Paper%20on%20Agriculture%20and%20Land%20Use.pdf>

⁷¹ <https://www.nationalruralnetwork.ie/eip-agri/>

engagement and ultimately strong stakeholder ownership of mitigation policies, which would help to achieve a just transition

In European Commission's December 2021, communication on sustainable carbon cycles, they outlined various approaches to capture and store or sequester carbon dioxide emissions including nature-based solutions. A key challenge will be to ensure permanence of carbon dioxide removals through actively managed natural processes and management practices in the land use, land-use change and forestry sectors. There are opportunities for Leitrim farmers to benefit from mitigation measures associated with land use.

Managing carbon pools at the level of the land manager or Carbon Farming⁷² involves actively supporting the natural carbon sequestration processes (focusing on the living biomass, (dead) organic matter, and soils), thereby removing atmospheric carbon. Two examples of potential carbon farming in Leitrim are:

- Restoration of peatlands and wetlands: raising the water table of drained peatlands or wetlands not only restores the hydrological balance of soils but also reduces oxidation of the existing carbon stock and increases the potential for carbon sequestration
- Agroforestry and other forms of mixed farming: land use management systems in which woody vegetation (trees or shrubs) are deliberately grown in combination with crop and/or animal production systems on the same land. Agroforestry has an important role in carbon sequestration, combining significant mitigation effects with co-benefits for ecosystems and biodiversity.

These mitigation measures are likely to bring multiple co-benefits, contribute to economic, social and environmental sustainability and are associated with essential, good land stewardship. The Commission are investigating results-based payment approaches for Carbon Farming. However, it requires more research to provide evidence-based payments. In the meantime, the new Breifni ACRES Cooperation Project will use proxies in their scorecard to provide a basis for carbon sequestration payments.

Hedgerows are a significant component of the Irish landscape, especially in Leitrim and provide a range of ecosystem and agronomic services (*c.f.*, Biodiversity section). The GEAI estimated that carbon sequestration by hedgerows, scrub and woodland was 21,800 t per annum.

⁷² <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021SC0450>

10 VALUING NATURAL CAPITAL AND ECOSYSTEM SERVICES.

Environmental valuation provides a means to demonstrate the value or importance people place on natural capital and ecosystem services⁷³. Most ecosystem services are public goods and do not have a market value. They are accessible for the benefit and enjoyment of everybody. However, they cannot be traded in the marketplace and have no market price or cost when positively or negatively delivered, respectively. The consequences are over-use or mismanagement of the natural capital, referred to in previous chapters.

In principle, the valuation process allows us to demonstrate the value people have for natural capital compared with the other factors contributing to their quality of life (*e.g.*, material goods like consumer goods traded in the marketplace). Such values will inform policymakers' decisions regarding farmer payments for the delivery of ecosystem services and where funds should be spent to restore, maintain and manage the natural environment. However, valuing natural capital is far from a simple process⁷⁴ and is beyond this project's scope.

Biodiversity is widely threatened, and payments from EU DG Agriculture can play an essential role in supporting biodiversity if allocated appropriately, especially when there is greater recognition of the part public payments can be made for ecosystem services.

It is of local interest to note a Leitrim high nature value grassland site was selected to participate in an EU-funded project to develop a results-based payment scheme for farmers⁷⁶. The species-rich grassland and locations for the March Fritillary.

The new ACRES Breifne Cooperation Project will use a results-based payment scheme to reward farmers for the quality of their habitats. The approach assesses the quality of a particular habitat using a scorecard. The higher the score, the higher the payment the farmer receives. The price received by the farmer depends on a range of quality criteria. It is analogous to the farmer's price for the meat sold to the factory.

The farmer payments are calculated based on income foregone and additional costs. It means that the price is based on the costs of delivering the required ecosystem service. The highest payment level (score of ten) is calculated based on the opportunity costs of achieving the target for the ecosystem service. For example, the loss in output value associated with extending a riparian zone beside a river and the management costs to deliver the zones biodiversity target.

⁷³ https://www.naturalcapitalireland.com/files/ugd/94066f_ad4020c0246441478965c56f3b82185e.pdf

⁷⁴

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/957498/ncc-natural-capital-valuation.pdf

⁷⁵ <https://www.conservation.org/projects/valuing-and-accounting-for-natural-capital>

⁷⁶ <https://rbaps.eu/pilot-areas/>