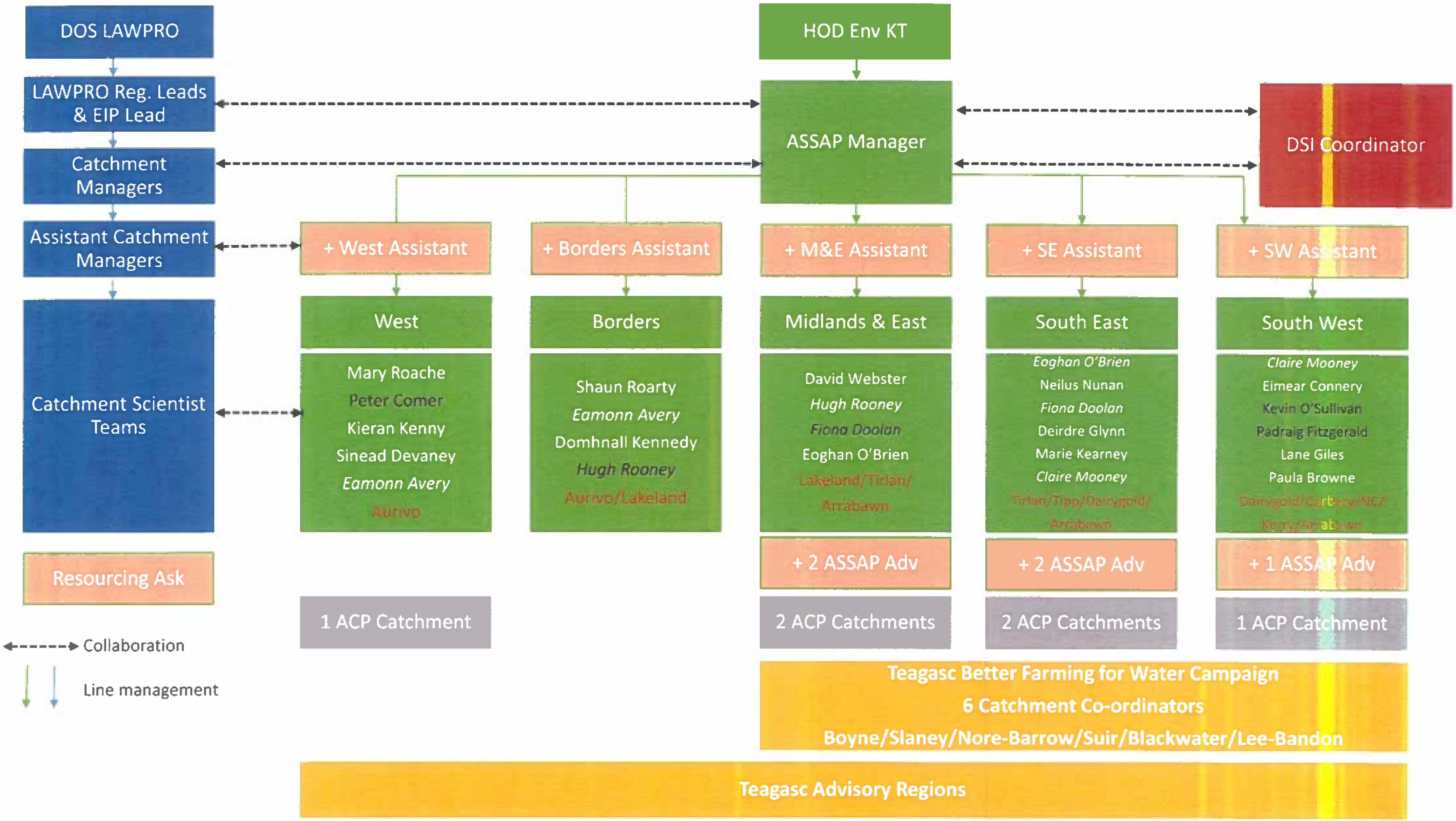

DOS LAWPRO
LAWPRO Reg. Leads & EIP Lead
Catchment Managers
Assistant Catchment Managers
Catchment Scientist Teams
Resourcing Ask
Collaboration
Line management
HOD Env KT
ASSAP Manager
DSI Coordinator
+ West Assistant
+ Borders Assistant
+ M&E Assistant
+ SE Assistant
+ SW Assistant
West
Mary Roache
Peter Comer
Kieran Kenny
Sinead Devaney
Eamonn Avery
Aurivo
Borders
Shaun Roarty
Eamonn Avery
Domhnall Kennedy
Hugh Rooney
Aurivo/Lakeland
Midlands & East
David Webster
Hugh Rooney
Fiona Doolan
Eoghan O'Brien
Lakeland/Tirlan/
Arrabawn
South East
Eoghan O'Brien
Neilus Nunan
Fiona Doolan
Deirdre Glynn
Marie Kearney
Claire Mooney
Tirlan/Tipp/Dairygold/
Arrabawn
South West
Claire Mooney
Eimear Connery
Kevin O'Sullivan
Padraig Fitzgerald
Lane Giles
Paula Browne
+ 2 ASSAP Adv
+ 2 ASSAP Adv
+ 1 ASSAP Adv
1 ACP Catchment
2 ACP Catchments
2 ACP Catchments
1 ACP Catchment
Teagasc Better Farming for Water Campaign
6 Catchment Co-ordinators
Boyne/Slaney/Nore-Barrow/Suir/Blackwater/Lee-Bandon
Teagasc Advisory Regions

Farming for Water EIP

- Teagasc have submitted 161 EIP Applications so far
- Focus on Farming for Water EIP applications over summer
- Recruitment of farmers needs to ramp up over the autumn period
- Advisors inviting farmers to meetings to provide information on EIP and recruit applicants
- N Surplus Training in Moorepark Sept 10th
- Provision of training for new ASSAP advisors (Teagasc and Co-op) to be provided on Oct 1 plus 2 more days to be confirmed

Better Farming for Water campaign

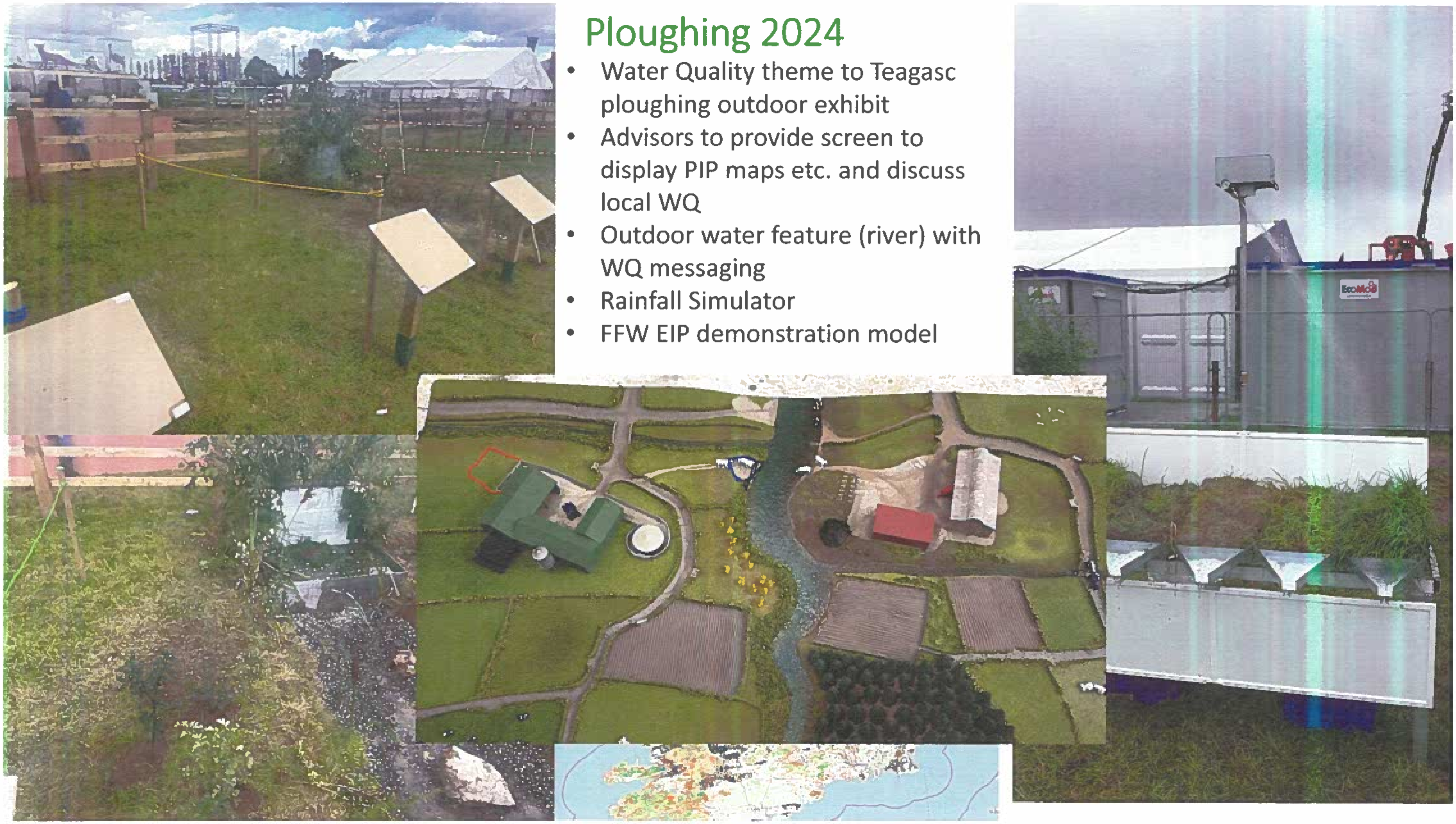
- 6 Catchment Co-ordinator posts advertised for BFFW campaign
- Joint BFFW/Signpost farm events planned across the 12 advisory regions in autumn
- Significant training programme for all Teagasc advisors also to be delivered in autumn

Engagement with Meat Industry

- Increased engagement with key meat processors and MII
- Opportunity to formalise MII/meat processors involvement in ASSAP

Ploughing 2024

- Water Quality theme to Teagasc ploughing outdoor exhibit
- Advisors to provide screen to display PIP maps etc. and discuss local WQ
- Outdoor water feature (river) with WQ messaging
- Rainfall Simulator
- FFW EIP demonstration model



53 ASSAP/LAWPRO/Co-op/Teagasc Water Quality Events to date in 2024

Date	Event	Location	Organised By
08/01/2024	Liquid Nitrogen Event & Water Quality Kilkenny	Teagasc Office Kilkenny	Teagasc, Hugh McEnneaney
07/02/2024	Water Quality Conference 2024	Tullamore	Teagasc
28/02/2024	Slaney Tillage Training	Enniscorthy	Teagasc
28/02/2024	SEROC Meeting	Ballykisteen Tipperarry	Tipp County Council
06/03/2024	Slaney Tillage Training	Enniscorthy	Teagasc
07/03/2024	Farming for Water EIP Launch	[redacted]	LAWPRO
07/03/2024	Use of Slurry and Water Quality Issues on Tillage Farms	Keypak Farm - Co Meath	Conor Callaghan & Hugh Rooney
21/03/2024	ASSAP and Advisors role in Water Quality in Kilkenny	County Council Offices Kilkenny	Deirdre Glynn & Richard O Brien
22/03/2024	World Water Day- Knocknagrave Community Centre	Monaghan	Tydavnet GWS
23/03/2024	Farm Management Students on ASSAP & Water Quality	Kildalton College	Cathal & Deirdre
04/04/2024	Sustainability Farm walk-Michael Smith- Mountnugent	Cavan	Teagasc/Liffey Meats
28/04/2024	ACRES CP	Monaghan	ACRES Breifini
21/05/2024	Scotstown Bluedot Pilot Project	Monaghan	Tydavnet GWS
28/05/2024	Farmers Meeting Linguan	[redacted]	Deirdre Glynn & Claire Mooney
29/05/2024	Woodlands for Water	Moorepark	Teagasc
29/05/2024	Signpost Partners Nitrate Workshop	Moorepark	Teagasc
31/05/2024	Farming for Water	[redacted]	Dairygold /Teagasc
12/06/2024	EPA Water Conference 2024	Galway & Online	EPA
20/06/2024	Teagasc Aurivo Focus Farm Walk	[redacted]	Teagasc/Aurivo JntPrg
21/06/2024	Farming for the Future	[redacted]	Tirlan
21/06/2024	Water Quality -	Gurteen College	Arrabawn
21/06/2024	Farm Peat - Training Day	Offaly	Farm Peat EIP
26/06/2024	Beef Event Grange	Teagasc Grange	Teagasc
28/06/2024	Farm Peat - Training Day	Roscommon	Farm Peat EIP
28/06/2024	water quality solutions event in West Cork	Castleross Hotel	Carbery
29/06/2024	Woodlands for Water Event	Teagasc Moorepark	Teagasc and Deirdre was a guide
04/07/2024	Greenfield Academy	[redacted]	Teagasc
10/07/2024	Farming Better for Sustainability	Killarney	Teagasc
10/07/2024	Ballyvaddin Open Day	Ballyvaddin Open Day	Teagasc & Dawn Boots
11/07/2024	Farming for Water	[redacted]	Dairygold
11/07/2024	Farming for Water EIP Farmer Info Mtg	Oughterard, Co. Galway	ACRES West Connacht/Teagasc
11/07/2024	Farming Better for Sustainability	Newcastle West	Teagasc
16/07/2024	Johnstown Castle Open Day	Johnstown Castle	Teagasc
16/07/2024	Teagasc Johnstown Castle	Johnstown Castle	Teagasc, Deirdre Glynn on ASSAP stand
23/07/2024	Tillage & Water Quality	[redacted]	Deirdre Glynn & Mark Trimble
23/07/2024	Farming Better for Sustainability	Pallasgreen	Teagasc
24/07/2024	Ministerial Visit(NI) to Emyvale	Monaghan	Teagasc
24/07/2024	Farming Better for Sustainability	Listowel	Teagasc
25/07/2024	Cathal Gaughrans Farm Collon Co. Louth. Signpost Beef Event with a large focus on Water Quality	[redacted]	
30/07/2024	Cover Crop Walk	[redacted]	Teagasc
31/07/2024	Teagasc Aurivo - Joint programme event Mountbellew Agric College	Mountbellew, Co. Galway	Teagasc/Aurivo JntPrg
01/08/2024	Cover Crop Walk	[redacted]	Teagasc
06/08/2024	Riparian Buffers and Nature Based Solutions	Curraghkehoe Co Kilkenny ([redacted])	Deirdre Glynn & Nore Vision Kilkenny
07/08/2024	Water Quality in Kilkenny	Ennisnag, Kells Kilkenny	Deirdre Glynn & Tennyson Private Consultants Kilkenny
08/08/2024	IFA Sustainability Walk	Cavan	IFA
08/08/2024	Wexford Tillage Farmers for Private Planners	New Ross	Deirdre Glynn & Tennyson Private Consultants Kilkenny
15/08/2024	Nitrates Derogation Course – "Farm Sustainability"	Teagasc Tuam, & on-farm Co. Galway	Teagasc
21/08/2024	Virginia Agricultural Show	Virginia	Teagasc
21/08/2024	Dawn Meats training on the ASSAP Programme	[redacted]	Cathal & Deirdre
24/08/2024	Iverk Show	Piltown Kilkenny	Teagasc, Deirdre Glynn on ASSAP
04/09/2024	Arrabawn Water Quality Farm Walk	Moneygall	Arrabawn
11/09/2024	Stand at Future Beef open Day	[redacted]	Teagasc

actors involved in water quality and agriculture, and promote stewardship and community involvement.

The Lead Advisors in the twelve advisory regions will be the ASSAP advisor and an enterprise advisor. They will have responsibility for co-ordination of the implementation of the campaign at advisory level to ensure advisory participation and farmer interaction.

4. Improvement of ASSAP governance

On-going evaluation of the governance of the ASSAP is allowing the process to evolve and continue to be fit for purpose going forward. The governance structures, procedures and mechanisms, and agreements are all necessary to ensure that the ASSAP continues to deliver from a water quality point of view and also value for the exchequer.

Oversight of the operational activities of ASSAP is provided by the ASSAP Oversight Committee. The day to day management of the ASSAP is provided by the ASSAP Co-ordination Group and the Farming Consultative Group provides stakeholder input into the programme. All have a defined membership and meeting structure.

Further to this all partners in the ASSAP; LAWPRO, Teagasc and the Dairy Processing Co-ops are preparing a memorandum of understanding to provide a clear agreement on roles, responsibilities and requirements to ensure delivery of the programme.

Proposal

Teagasc ASSAP proposes to:

- Retain the existing ASSAP advisory structure based on the Teagasc regional advisory structure
- To align ASSAP advisors within the relevant advisory regions to the six catchments identified by Teagasc under the Better Farming for Water campaign
- Add additional ASSAP advisors (five) to regions where there is a under resourcing issue
- Add additional catchment co-ordinators (three) to meet the Catchment Co-ordinator requirement under the Teagasc under the Better Farming for Water campaign
- The three catchment co-ordinators would provide support to the ASSAP manager in managing ASSAP advisors workload in the Midlands and East, South East and South West regions and to improve collaboration and interaction with LAWPRO at regional level. The ASSAP manager will provide the same role in the Borders and West regions.
- ASSAP advisors will continue to have the Regional Managers as their direct line managers. The requirement of the three catchment co-ordinators to provide management of the delivery of advisor work programmes will result in greater visibility of progress and identification of barriers
- It also retains the integration of ASSAP in the advisory structures which has an increased importance due to the Better Farming for Water campaign
- Removal to a stand-alone unit under direct management of the ASSAP manager will lead to additional admin burden and require a review of the existing funding structure

Existing ASSAP Advisory Structure		Proposed Structure			
Advisor	**Advisory Region**	**Advisor**	**Advisory Region**	**Catchment**	**Resourcing Request**
Shaun Roarty	Donegal	Shaun Roarty	Donegal		
Eamonn Avery	Sligo Leitrim	Eamonn Avery	Sligo Leitrim		
Peter Comer	Mayo	Peter Comer	Mayo		
Mary Roache	Mayo	Mary Roache	Mayo		
Sinead Devaney	Galway	Sinead Devaney	Galway		
Paula Browne	Clare	Paula Browne	Clare		
Padraig Fitzgerald	Limerick	Padraig Fitzgerald	Limerick		
Kevin O'Sullivan	Kerry	Kevin O'Sullivan	Kerry		
Ciaran Kenny	Roscommon Longford	Ciaran Kenny	Roscommon Longford		
Domhnall Kennedy	Cavan Monaghan	Domhnall Kennedy	Cavan Monaghan Westmeath		
David Webster	Westmeath Offaly	David Webster	Cavan Monaghan Westmeath		
Hugh Rooney	Louth Meath Dublin	TBC	Offaly	Mid Shannon - Offaly & North Tipperary	ASSAP advisor
Fiona Doolan	Kildare Laois	Hugh Rooney	Louth Meath Dublin	Boyne & Louth / Dublin	ASSAP & CC (Boyne) ***Midlands & East***
Nielus Nunan	Wexford	Fiona Doolin	Laois Kildare	North Barrow & North Nore	ASSAP & CC (Barrow Nore)
Eoghan O'Brien	Wicklow Carlow	Deirdre Glynn	Kilkenny	South Barrow & South Nore & East Suir	
Deirdre Glynn	Kilkenny	Nielus Nunan	Wexford	Slaney	ASSAP & CC (Slaney) ***South East***
TBC	Waterford	Eoghan O'Brien	Wicklow Carlow	South Barrow & Wicklow	
Lane Giles	Cork West	Eimear Connery	Cork East	Blackwater	ASSAP & CC (Blackwater)
Eimear Connery	Cork East	Lane Giles	West Cork	Lee / Bandon	CC (Lee Bandon) ***South West***
Claire Mooney	Tipperary	Claire Mooney	Tipperary	Suir	CC (Suir)
		Vacant	Waterford	East Blackwater & Waterford	

Figure 2: the existing ASSAP structure is in green with the proposed ASSAP structure in blue

ASSAP Structure Review and Business Case for Additional ASSAP Resources

Introduction:

The ASSAP Oversight Committee requested a review of the overall ASSAP work programme from 2024 to the end of 2027, specifically covering Teagasc ASSAP workload in relation to the Water Framework Directive obligations, referrals from LAWPRO and KT, and also the new Farming for Water EIP. The recent launch of the Teagasc Better Farming for Water Campaign will also need to be considered in relation to additional requirements on existing Teagasc ASSAP resources.

This review of work programme highlighted the following:

1. An imbalance in the advisor workload across the Teagasc Advisory Regions related to the scale of impact on water quality. In general the south and east of the country have greater levels of impacted water bodies some regions in the border area also having a deficit
2. A requirement for improved oversight of advisors and improved co-ordination and interaction with LAWPRO management at regional level
3. A need to review the structural management of ASSAP by Teagasc and also to align with the delivery of the Better Farming for Water Campaign
4. A need to improve overall ASSAP governance through
   - a Memorandum of Understanding between Teagasc, the dairy processing co-ops and LAWPRO
   - structure of meetings and reporting to DAFM, DHLGH and LAWPRO

Discussion

1. Imbalance in advisory workload across regions:

Figure 1: Breakdown by Teagasc advisory region of the number of farms for potential EIP applications, existing referrals issued to advisors and expected referrals in 2024 on a per advisor basis.

Region	Potential EIPs	Farms in Existing Referrals	Farms in 2024 Referrals	Total per Advisor
Tipperary	53	74	140	267
Waterford	70	10	100	180
Westmeath/Offaly	47	88		135
Cavan/Monaghan	71	178		249
Sligo/Leitrim	59	106		165
Cork East	108	55	40	203
Wicklow/Carlow	135	280		415
Laois/Kildare	117	241	165	523
Dublin/Meath/Louth	100	220		320
Kerry	20	2		22
Roscommon/Longford	90			90
Cork West	43	43	3	89
Mayo	40	10		50
Mayo	135	137	20	292
Wexford	109	30	45	184
Limerick	42	129		171
Clare	35			35
Donegal	163	238		401
Galway	185	25		210
	1622	1866	513	

Based on figures from advisors and information from LAWPRO the Figure 1 provides an indication of workload for advisors across the Teagasc regions for 2024. As can be concluded from the table for some advisors the numbers of farms to be assessed under ASSAP and EIP applications required is greater than the capacity of the advisor to deliver in a timely manner. Advisors with a lower level of projected workload from referrals will be required to increase EIP applications by moving to restore and protect cycle 3 PAAs based on LAWPRO guidance.

The current structure for advisors is further complicated by the Teagasc Better Farming for Water Campaign that proposes to follow a catchment based approach across eight catchments in the east and south of the country and the requirement for ASSAP to aid in the resourcing of three of the six proposed catchment co-ordinators to lead the implementation of the campaign.

2. Improved oversight of advisors and improved co-ordination and interaction with LAWPRO management at regional level

The management of ASSAP advisors is divided between line management and management of the programme. Line management is carried out by the advisors Regional Manager who provides administrative and programme delivery supervision at regional unit level. The ASSAP manager ensures that the programme is operational and collaborative, and integrated with the requirements under WFD, EIP, etc. and meets its reporting requirements.

The recent addition of the Ag Planner software for capturing ASSAP data improves the reporting capabilities and lowers the administrative burden; and the appointment of an Environment Specialist will aid in the provision of specialist support to ASSAP advisors and the wider advisory service.

Management of the ASSAP advisors at LAWPRO regional level is key to delivery of both ASSAP assessments and EIP applications. This collaboration is managed through a quarterly meeting structure with further advisor/catchment scientist meetings occurring as necessary. The addition of LAWPRO Assistant Catchment Managers to help administer LAWPRO activities needs to have a similar structure in ASSAP. This will greatly improve the day to day management of work programmes, collaboration, feedback, implementation of measures and reporting.

3. Review of management structure of ASSAP alignment with the delivery of the Better Farming for Water Campaign

Teagasc has undertaken to deliver a multi actor water quality campaign to support and accelerate the adoption of actions on all farms to improve rivers to good or high ecological status. To deliver on the campaign to the wider AKIS Teagasc will be required to exploit existing resources. This will include the appointment of six Catchment Co-ordinators and Lead Advisors in each of the twelve advisory regions.

The six catchment co-ordinators will be located in the catchments identified by the EPA in the 2021 report 'Assessment of the catchments that need reductions in nitrogen concentrations to achieve water quality objectives'. The catchments are; Boyne, Slaney, Nore/Barrow, Suir, Blackwater and Lee/Bandon. Teagasc proposes to appoint three staff from existing advisory resources and three staff from ASSAP advisory resources to the posts. The Catchment Co-ordinators will be responsible driving the collaborative effort on a catchment scale across all

An Roinn Talmhaíochta,
Bia agus Mara
Department of Agriculture,
Food and the Marine

Nitrates Action Programme - Ireland

Derogation Report 2023

Interim Report, updated 12/07/2024.

Report for 2023 for the purposes of Articles 10, 11 and 13
of the Commission Implementing Decision 2022/696 of 29th April 2022 granting
a derogation requested by Ireland, pursuant to
Council Directive 91/676/EEC.

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1. Introduction

Background

Regulations giving statutory effect to certain elements of Ireland's first Action Programme under the Nitrates Directive were enacted in 2005 i.e. the European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2005 (S.I. No. 788 of 2005). Through the second, third, fourth and fifth Nitrates Action Programmes (NAP) the Regulations were subsequently replaced and strengthened.

The most recent legislation following the NAP Review in 2022 is the European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2022 (S.I. 113 of 2022) (as amended). It provides Ireland's strongest set of regulations yet to protect water from pollution caused by agricultural sources.

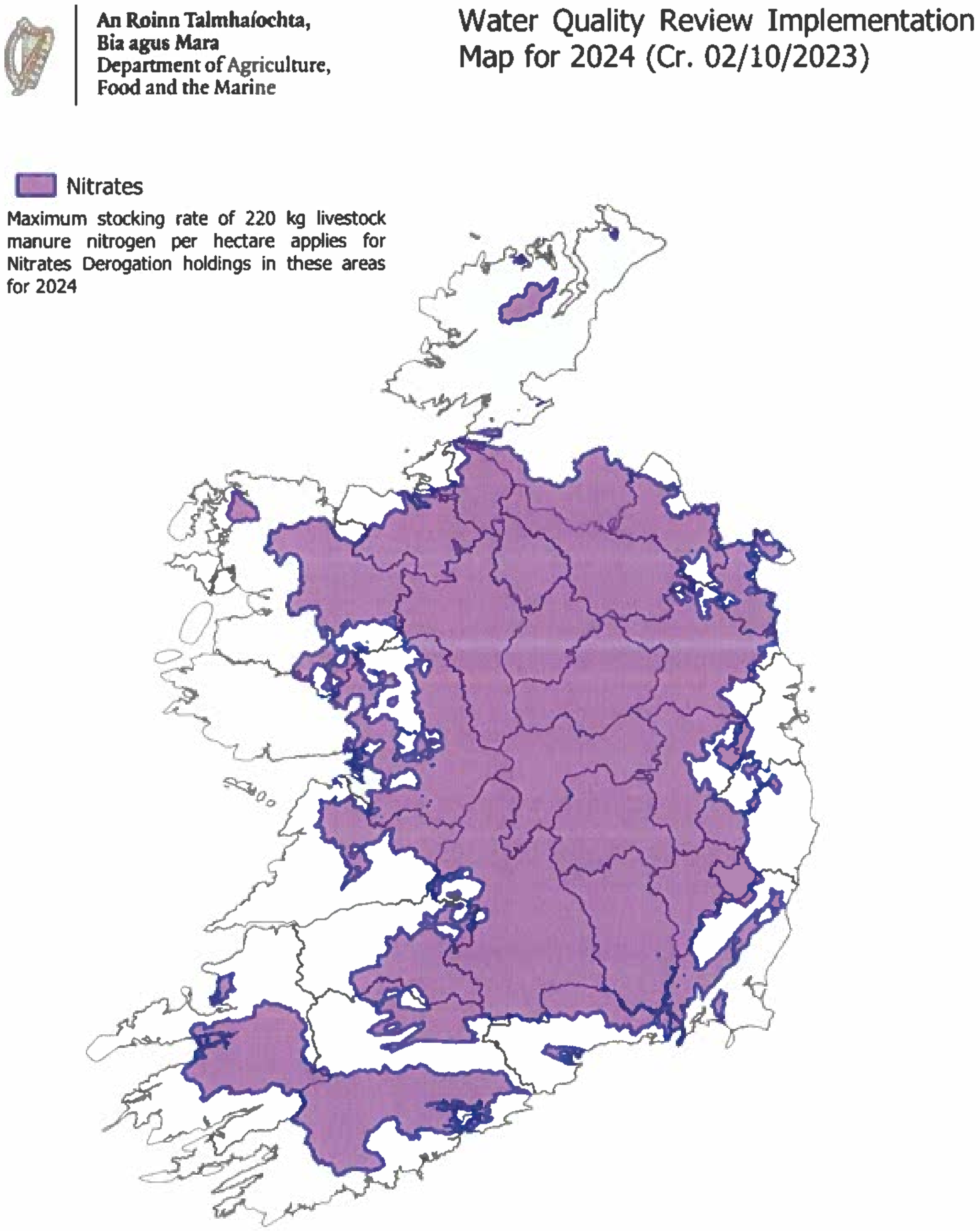
Ireland's first Nitrates Derogation was granted by the European Commission in October 2007 (2007/697/EC). Like the Regulations associated with the NAP, Ireland's Nitrates Derogation has gone through several iterations over the years.

Up to an including 2023, farmers with a nitrates derogation were permitted to apply up to 250 kg livestock manure nitrogen (N) per hectare (ha). However, Article 12 of the European Commission Implementing Decision (EU) 2022/696 granting Ireland's current Nitrates Derogation, required Ireland to undertake a two-year review of water quality in 2023. As part of the interim review, a reduction in the maximum permitted limit of Nitrogen to be applied on the majority of holdings in receipt of a Nitrates Derogation came into effect from 1st January 2024 as illustrated overleaf in Figure 1.1.

Article 10 of the Commission Implementing Decision granting Ireland's current nitrates derogation requires maps showing information concerning approved derogations on a county basis to be submitted annually to the Commission. Article 10 also requires certain monitoring activities to take place while Article 11 sets out the controls that must be undertaken with regard to derogation applicants. Article 13 sets out the reporting requirements for the purposes of the Commission Decision.

This report is submitted to address the requirements of Articles 10 and 13 and relates to operation of the derogation in Ireland during 2022 and 2023, where available.

Figure 1.1. Water Quality Review Implementation Map for 2024 showing in purple the areas that are at maximum stocking rate for derogation of 220 kg N/ha from 1st January 2024 onwards.



Ireland's proactive approach to further reducing the impact of agriculture on the environment

Ireland is working collaboratively across Government and its State Agencies to collectively protect water quality. The Department of Housing, Local Government and Heritage (DHLGH) is the lead authority for the Nitrates Regulations (SI 113 of 2022, as amended). They work closely with the Department of Agriculture, Food and the Marine (DAFM) as well as the Environment Protection Agency (EPA) in this regard.

DAFM implements and operates the Nitrates Derogation. The EPA is responsible for monitoring and reporting environmental indicators. Teagasc, both at research and advisory level, is actively researching and promoting mitigation measures for farmers.

A full review of Ireland's NAP concluded in March 2022. This resulted in significant changes for farmers with several new measures being introduced, while certain existing measures were made more robust or expanded to cover more farmers. These changes were further enhanced with a suite of requirements that applicants were required to comply with from 2023. Further changes came into force from January 2024 and there will be further measures for the 2025 programme. A review of the NAP took place in 2023. It is still undergoing the Appropriate Assessment and the Strategic Environmental Assessment processes (June 2024). Once that process is completed further measures to protect and improve water quality are intended to be introduced under the 5th NAP.

In 2022, DAFM requested Teagasc to update modelling on the impact (environmental and economic) of a number of farm nitrogen mitigation measures in order to inform policy of the best current and potential actions to deliver the catchment-based nitrate load reduction estimated as required by the EPA. This is published and available at: 2023 - The Impact of Nitrogen Management Strategies within Grass Based Dairy Systems - Teagasc | Agriculture and Food Development Authority.

It is anticipated that N losses from Irish Nitrates Derogation grassland farms will reduce significantly over the coming years due to a significant reduction in chemical N application rates, changes to slurry management and soiled water storage, higher livestock N excretion rates plus "banding" of nutrient excretion rates and an extended closed period for chemical fertiliser application.

It is estimated that Ireland's 5th NAP will result in a reduction of between 5.9 and 9.0 kg/ha of nitrate-N leeched to one metre level on a grass only based system (Shalloo *et al.*, 2023). These reductions, albeit at a 1m level, will have a significant impact on achieving the requirements of N reductions required at a catchment level identified by the EPA (WFD River Basin Management Plan – 3rd Cycle in draft), as required to achieve a water quality standard of 2.6 mg N/l in the downstream estuary.

In the WFD River Basin Management Plan – 3rd Cycle report (in draft) some catchments required virtually no N load reductions, while others required various levels of reduction. Five catchments required no N reductions entering the water (Avoca, Corrib, Erne, Fergus, Moy), eight required reductions of under 3kg N/ha annually (Blackwater, Deel, Dodder, Lee, Liffey, Maigue, Suir and Tolka) while four required reductions of greater than 3kg N/ha annually (Bandon, Boyne, Nore, Slaney) across their total areas. The range of reductions of N entering the water required was 0 to 18.7 kg N/ha annually across the total catchment area.

Not all the area in a catchment is farmed, and therefore to achieve the levels of load reduction entering the estuary stipulated by the River Basin Management Plan – 3rd Cycle report (in draft), significantly higher reductions would be required on a per hectare farmed basis. If this analysis was completed assuming that all the reductions would be made in the critical source areas for loss as identified by the EPA in each catchment, the reductions needed would be higher still. For example, in the Blackwater catchment the load reductions would be approximately 5.4 kg N/ha, while in the Slaney the reductions required would be 43 kg N/ha if all the reductions are to be achieved within the critical source areas. In reality, the load reductions required will be somewhere between the critical source area and total area calculations for each of the catchments.

There have been many changes to policy (NAP and Food Vision 2030) that will have a substantial effect at reducing nitrate losses from farms. These reductions will have a significant impact on achieving the required targets, however they need time to demonstrate their full impact on water quality.

While the full impact of reducing the maximum stocking rate from 250 kg N/ha to 220 kg N/ha for most of Ireland's nitrates derogation farmers is yet to be seen, it is anticipated that the reduction will result in a shift away from grassland farming towards more cropping and indoor-based systems to achieve higher milk production per cow as the avenue to increase output when stocking rate limits reduce. This would have a negative impact in Ireland from both a climate change, water quality, biodiversity and an animal welfare perspective.

In grass-based systems there is a very strong relationship between overall farm financial performance and grass utilised per hectare (Hanrahan *et al.*, 2018). The two key drivers of grass utilisation are stocking rate and supplementary feed levels. Any strategy that reduces overall stocking rate below the grass growth and utilisation capacity of the farm will reduce farm profitability and will potentially reduce the sustainability of pasture-based systems.

Increased grass utilisation has accounted for 69% of the increase in productivity in Irish dairy farms between 2010 and 2020 (Dillon *et al.*, 2020). The number of grassland farmers using 'PastureBase Ireland' (A web-based grassland decision support tool) has increased significantly in recent years to 6,000 users in 2023, up almost three-fold from 2,300 users in 2017.

Knowledge of farm grass cover (grass availability on farm) and current grass growth rates has led to more efficient use of grazed grass. Additionally, increased grass production combined with higher grass utilisation will result in increased nitrogen use efficiency. The average grass production on dairy farms, using 'PastureBase Ireland' is approximately 14t DM/ha per year, facilitating a farm stocking rate of approximately 2.5 cows/ha, assuming a concentrate supplementation level of 500 kg/cow. At an organic N output of 92 kg per cow this equates to a stocking rate of 230 kg N/ha. For grassland farmers that can produce greater than 14t DM/ha, the appropriate stocking rate from a grass utilisation perspective is in excess of 2.5 cows/ha.

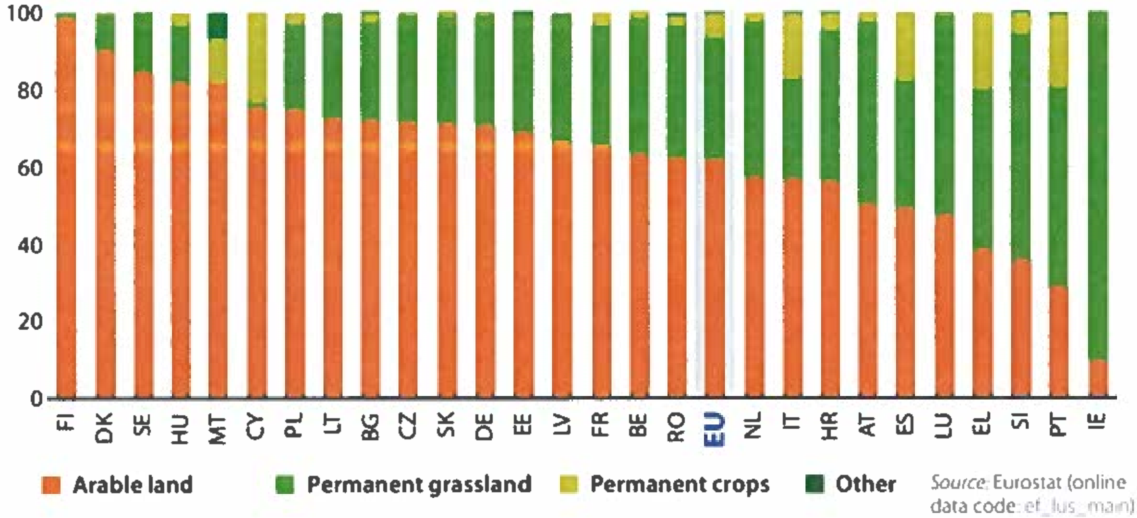
The reduction of maximum stocking rate from 250 kg N/ha to 220 kg N/ha from 2024 will result in reduced pasture utilisation on Irish farms. There is a very high risk that if farms are restricted further on stocking rate that they would change management at farm level to increase milk yield per cow. This will result in a reduction in food security and a move away from Ireland's traditional grass-based system, through an increased use of purchased and imported grain. Such a change will also result in a higher N surplus at farm level (which has an increased risk of N loss) and a reduction in farm profitability (Shalloo *et al.*, 2023).

Land use

Data from Eurostat shows that Ireland had by far the highest percentage of utilized agricultural area under grassland at 90.4%; the next highest is Slovenia at 58.4% (Figure 1.2).

Pasture based systems confer environmental advantages in terms of manure recycling, soil organic carbon content, feed self-sufficiency (including protein), greenhouse gas emissions per kilogram of product, and landscape diversity.

Figure 1.2. The utilisation of agricultural land in EU member states 2016 (Eurostat, 2017)



Agriculture landscape

The Irish agriculture landscape is heterogeneous where both static (e.g. soil and bedrock type, thickness and permeability) and dynamic factors (e.g. climate, soil moisture deficit, water table depth) influence N leaching. The Irish Agricultural Catchment Programme (ACP) is in place since 2008 and is used to evaluate the impact of Ireland's Nitrates Action Programme and the Nitrates Derogation on water quality. The programme is a collaboration with over 300 farmers in six river catchments to represent agricultural land with different levels of risk associated with N and P losses which are operated under differing enterprises.

The ACP research highlights the overriding importance of agronomic, meteorological and hydrogeological factors in controlling N and P losses to water. Similar impacts have also been reported more recently by Dillon *et al.* (2021) when evaluating the impact of nitrogen management on N loss pathways. In 2018 a nation-wide drought caused a build-up of a large soil N pool due to poor grass growth and enhanced soil N mineralisation, which was compounded by increased use of artificial N as well as increased purchased feed. This ultimately resulted in elevated nitrate-N concentrations in waterbodies during late 2018 and early 2019 (Mellander and Jordan, 2021). Analysis of the ACP data suggests that a four-year inter-annual analysis is required to show annual trends in water quality.

Subsequent analysis showed that the impact of the drought in 2018 on elevated nitrate-N concentration on surface and ground water could have been largely reduced by operating more precise grazing and fertiliser management at farm level when grass growth rates were significantly below normal (Shalloo *et al.* 2023). Since 2018, improved fertiliser application guidelines have been issued to farmers to reduce N losses on farms directly after periods of dry summer conditions and for early nitrogen advice in the permitted period in the Spring. Based on scientific research, it is considered that under Irish conditions, the implementation of precision fertilizer application strategies will have a much greater impact in improving water quality than reducing the maximum stocking rate.

Farming system

Irish grass-based systems of milk and meat production rely on the conversion of human inedible forage into highly nutritious and digestible human-edible products. O'Brien *et al.* (2018) reported that the average diet of Irish dairy cows was 81.8% forage, with concentrates constituting just 18.2% of the annual feed budget on a dry matter basis. Of the 81.8% forage, 60.2% was grazed pasture, 19.8% was grass silage, and 1.8% was alternative forages. This is significantly different to farming systems in most other EU countries.

Results from the ACP show that the change in the percentage of land in derogation within the *Timoleague* catchment was not reflected in water quality change in the streams. The *Timoleague* catchment is dominated by grassland and has the most land in derogation (66% in 2018). Despite an increase in organic N loading in the catchment from 134 to 182 kg/ha over the period 2008 to 2018, there was no statistically significant temporal trend in the ground water nitrate-N concentration during the 2010 to 2017 period (McAleer *et al.,* 2022).

In contrast in the *Castledockerell* catchment, which was dominated by spring barley, where there was a low annual organic N loading with a minor increase from 35 to 45 kg/ha from 2008 to 2018; there was a higher groundwater nitrate-N concentration compared to *Timoleague*, as well as a positive trend in nitrate-N concentration during the 2010-2017 period (McAleer *et al.,* 2022).

Stabilisation of national herd

After more than a decade of growth, data released by the Central Statistics Office (CSO) in 2023 points to a stabilisation in the Irish national dairy cow herd. Ireland's national statistics office reported that there were 1.510 million dairy cows in Ireland. As detailed in Table 1.1 below, this is a mere increase of just 500 head when compared to the corresponding period in 2022.

Additionally, the slight growth in dairy cow numbers from 2022 to 2023 follows a much reduced level of growth between the 2021 and 2022 statistical years, when the national dairy cow herd increased by 5,000 head – moving from 1.505 million cows to 1.510 million cows. What preceded the abovementioned changes in the national dairy cow herd was a rapid rate of expansion following the removal of milk quotas in 2015.

Table 1.1. Change in Ireland's Dairy Cow numbers 2011 – 2023. Source; Central Statistics Office (CSO)

Year	Head ('000)	Change since previous year (head)
December 2011	1035.60	-
December 2012	1060.30	24,700
December 2013	1082.50	22,200
December 2014	1127.70	45,200
December 2015	1239.90	112,200
December 2016	1295.20	55,300
December 2017	1343.30	48,100
December 2018	1369.10	25,800
December 2019	1425.80	56,700
December 2020	1456.00	30,200
December 2021	1505.30	49,300
December 2022	1510.30	5,000
December 2023	1510.90	500

Total cattle numbers were down by 25,900 head (0.4%) to 6.526 million between 2022 and 2023 as detailed in Table 1.2.

Table 1.2. Change in Ireland's Cattle numbers 2021 – 2023. Source; Central Statistics Office (CSO)

Description	December 2021	December 2022	December 2023	Change 2022 - 2023	
		'000		'000	%
Total cattle	6,649.3	6,551.8	6,526.0	-25.9	-0.4
Dairy cows[1]	1,505.3	1,510.3	1,510.9	0.5	0.0
Other (suckler) cows	889.7	861.7	818.6	-43.2	-5.0
Bulls[2]	48.2	46.2	47.3	1.0	2.2

[1]Dairy cows are those kept principally to produce milk for human consumption.

[2]Bulls used for breeding purposes only

Impact of reducing stocking rate on N leaching (or organic N/ha)

Stocking rate is a key farm-level efficiency factor in successful grazing systems which facilitates the achievement of high levels of grazed pasture utilisation and milk production per hectare on dairy farms (McCarthy *et al.,* 2011). In defining the optimum stocking rate for resilient, pasture-based grazing systems, pasture utilisation is the principal considerations driven by good soil fertility, productive swards of perennial ryegrass and white clover.

In Table 1.3, the optimum stocking rate is defined for farms that produce different amounts of pasture and feed different amounts of supplement.

Table 1.3. Stocking rate that optimises profit on farms growing different amounts of pasture grown and feeding different amounts of supplement/cow. *Source: Teagasc Moorepark*

	Pasture grown, t DM/ha				
Supplement fed/ha, t DM	**12**	**14**	**16**	**18**	**20**
0.00	1.9	2.2	2.6	2.9	3.2
0.25	2.0	2.3	2.7	3.0	3.3
0.50	2.1	2.4	2.8	3.1	3.5
1.00	2.3	2.6	3.0	3.4	3.8
1.50	2.5	2.9	3.3	3.7	4.1

Although the beneficial impacts of stocking rate on grazing system productivity have been widely reported, the impact of stocking rate on environmental efficiency must also be considered.

Previous studies have indicated that where increased stocking rate is associated with increased chemical N fertiliser and supplementary feed importation, nutrient-use efficiency is reduced, nitrogen surplus is increased, resulting in increased N available to be lost to ground water and the general environment (Di and Cameron 2002; Treacy *et al.,* 2008; Ryan *et al.*, 2011). Contrary to these findings however, both McCarthy *et al.* (2015) and Roche *et al.* (2016) investigated the direct effect of stocking rate on nitrate leaching. Both studies reported either a stable or declining nitrate leaching with increasing stocking rate; the critical proviso, however, was that strictly no additional N fertiliser or supplements were introduced at higher stocking rate.

Shalloo *et al.* (2023) also modelled the impact of reducing stocking rate on N leaching. With chemical N input of 250 kg N/ha, reducing stocking rate from 250 kg N/ha to 230 kg N/ha or 220 kg N/ha resulted in reduction of N leaching by 1.5 kg N/ha and 2.2 kg/ha respectively at 1m depth.

Shalloo *et al.* (2023) also used models to predict the impact of reduced chemical N on leaching at different stocking levels. Reducing chemical N to 225 kg, 200 kg and 175 kg N at a stocking rate of 250 kg N/ha resulted in reduction in N leaching to 1m by 1.3-2 kg N/ha, 2.7-4 kg N/ha and 3.9-6 kg N/ha respectively.

The 5th NAP introduced a reduction in fertiliser allowances and lower limits for lower stocking rates. Shalloo *et al.* (2023) concluded that the new measures of dairy banding and reduced chemical N allowances along with the reduction of the derogation stocking rate limit of 250 kg N/ha to 220 kg N/ha in some areas would result in reduction of N leaching of between 5.9 kg N/ha and 9 kg N/ha.

On the basis of improved management practices, it is not correct to assume that N loss/ha through leaching increases as grass utilisation increases through increased stocking rate. Huebsch *et al.* (2013) showed that the nitrate-N concentration in groundwater in a free draining soil in Ireland declined over 11 years, despite a 20% increase in stocking rate. The reduced N leaching was associated with changes in management practices that included reduced chemical N fertiliser usage, improvements in timing of slurry application, increased precision grazing management, the movement of a dairy soiled water irrigator to areas deemed less vulnerable to leaching, and the use of minimum cultivation at reseeding. While Richards *et al.*, (2015) showed a reduced N surplus through reduced stocking rates and fertiliser levels in beef systems was associated with reduced N loss with the reduced N surplus component similar to the McCarthy and Roche studies.

2. Operation of the Derogation in 2023

The documentation associated with the administration of the Nitrates Derogation in Ireland in 2023 is shown in *Appendix 3*.

3. Applications

The number of applications received for the derogation in 2023 increased significantly compared to previous years. This is considered to be due to the banding of dairy cow excretion rates rather than an increase in livestock numbers on Irish farms. As outlined above, CSO data shows the national dairy herd was stable across the years 2022 and 2023 and the overall cattle herd declined slightly.

Under "banding" the majority of dairy herds saw an increase in the dairy cow excretion rate of at least 3% in 2023 compared to 2022. Dairy cow excretion rate increased by 19% in 2023 for herds assigned to the highest excretion rate band. These changes resulted in a significant number of additional farmers applying for the derogation in in 2023 compared to 2022.

Table 3.1. Summary of derogation applications 2015-2023.

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023
Applications received	6,330	6,804	6,995	6,897	6,684	6,505	6,814	6,726	7,298
Applications finally approved	5,997	6,533	6,557	6,554	6,308	6,016	6,426	6389	*

Note*The 2023 application process resulted in applications from a total of 7,298 herdowners. Eighty-eight of these applicants were deemed ineligible to apply based on the requirement set out in Article 11(3) of the Commission Implementing Decision and the outcome of controls conducted regarding their 2022 derogation application. Separately, every year a proportion of applicants subsequently voluntarily withdraw their application. These withdrawals combined with the outcome of the Department of Agriculture, Food and the Marine's controls regarding the 2023 applications will result in the number of applications that are finally approved for the year in question. To date 150 applicants have been identified as voluntarily withdrawing their application. The administrative compliance check for 2023 is still underway and the final figures for those approved is not yet finalised.

4. Description of Maps

Derogation Decision – Monitoring Requirements set out in Article 10 (1)(a)

Maps showing the percentage of grassland farms, the percentage of livestock and the percentage of agricultural land covered by authorisations in 2022 for each County, as well as maps on local land use, as referred to in Article 10(1) for 2022 are shown in Appendix 4; the three maps are based on the numbers of approved nitrates derogation applications in 2022.

Map 1: ***Percentage of holdings with grazing livestock encompassed by derogation in 2022 at county level.***

Map 1 categorises the number of derogation holdings as a percentage of the total number of holdings in the country with cattle and or sheep, on a county basis. Counties are categorised into one of four categories (less than 3%, between 3% and 5%, between 5% and 10% and greater than 10%).

Map 2: ***Percentage of grazing livestock units encompassed by derogation in 2022 at county level.***

Map 2 categorises the number of grazing livestock units (one grazing livestock unit = 89kgs N from cattle or sheep manure) on approved derogation holdings as a percentage of the total grazing livestock units in the country, on a county basis. Counties are categorised into one of four categories (less than 3%, between 3% and 5%, between 5% and 10% and greater than 10%).

Map 3: ***Percentage of net area encompassed by derogation in 2022 at county level.***

Map 3 categorises the total net area on approved derogation holdings as a percentage of the total net area in the country, on a county basis.

Derogation holdings accounted for 5.14% of the total number of holdings with cattle and or sheep in the country in 2022. 23.59% of the total number of grazing livestock units were on derogation holdings in 2022. Derogation holdings accounted for 10.54% of the total net area of the country in 2022 as referred to in Appendix 1.

Maps for the grassland farms covered by authorisations in 2023 for each County as referred to in Article 10(1) will follow when all checks regarding 2023 have been completed and the final number of approved applicants is confirmed. In the absence of these final maps, a map showing the locations of 2023 Nitrates Derogation applicants is presented in Appendix 2.

5. Controls

Derogation Decision – Reporting Requirements – Article 13(g) an evaluation of the implementation of the conditions for the authorisations on the basis of the results of the administrative controls and field inspections referred to in Article 11(1) and (2);

Farmers wishing to avail of the derogation were obliged to submit a 2023 online Nitrates Derogation application to the Department of Agriculture, Food and the Marine (DAFM) by 14th April 2023.

Farmers who availed of the derogation facility in 2023 were required to submit fertiliser accounts by 31st March 2024 as required under Article 6(3) of the Commission Implementing Decision.

DAFM operates a fully integrated control framework with regard to the derogation consisting of administrative controls in respect of all applications which is complemented by a programme of audits and inspections at farm level which are conducted on a risk basis to ensure the requirements set out in the Commission Implementing Decision are effectively complied with and enforced.

Farm audits may take place at any time of year, however, to maximise the value of the control effort, inspections are targeted to the risk and to the level of compliance expected in the relevant situation.

5.1. Administrative checks

Administrative checks on applications/fertiliser accounts

A database of all derogation applications received was generated. The following administrative checks were undertaken for all applicants:

- Eligibility to apply for a derogation in 2023 was assessed based on the outcome of controls on derogation applicants relating to the previous year (2022).
- Derogation applicants' particulars were checked against the Department's Corporate Customer System (CCS) by means of the herd number supplied.
- Check the necessary supporting documentation and fertiliser records have been submitted.
- Type of livestock on holding – checked that farmer had grazing livestock (consulted other Department databases).

- Declared area of holding checked re 80% grassland requirement.
- Compliance with the maximum limit of 250kg N/ha from grazing livestock manure.
- Quantities of livestock manure exported to other holdings (if applicable).
- Check if herd restricted from a disease control perspective.
- Deadline for receipt of completed Record of movement of organic fertiliser (Record 3) forms, if applicable, was 31st December 2023.
- Deadline for receipt of Short-Term Rental Grazing Agreement (Record 5) forms, if applicable, was 31st December 2023.

5.2. Results of administrative checks

Table 5.2.1 provides a breakdown of the numbers of derogation applicants and the results of administrative checks for 2023.

Table 5.2.1. Numbers of derogation applicants and the results of administrative checks 2023

Total applications received	7298
Ineligible applications based on the outcome of controls relating to applications submitted in the previous year	88
Number of potentially valid applications received	7210
Number of applications withdrawn by applicant, based on admin checks conducted to date as of 28/06/2024*	150
Number of applicants rejected based on administrative checks, as of 28/06/2024 (checks ongoing)	47
Number of applications finally approved following admin and field checks	Checks ongoing

**Note:* *Withdrawing from derogation is only possible within the year of derogation and prior to the notification of an audit/inspection or the outcome of any administrative checks. The administrative checks consist of checks on each herd number that has applied for an authorisation. As these checks are completed the number of authorisations that withdrew is calculated following a cross-check. These cross-checks are ongoing and there may be further applicants which have withdrawn in 2023, however it is not possible for an applicant to withdraw their application once the year has ended.*

5.3. Administrative Penalties (for breaches of Nitrates Regulations)

As part of the controls under the Nitrates Regulations, DAFM carries out a 100% administrative check on all herdowners (derogation and non-derogation) with livestock on an annual basis. This check requires compilation of the total quantity of organic Nitrogen (N) for every herd from DAFM's Animal Identification and Movement System (AIM) together with organic N excretion rate data, divided by the declared area of land under the Basic Income Support for Sustainability (BISS) Scheme, to arrive at a kg organic N per hectare figure for each herd. Herdowners in breach of the 170/250 kg per hectare limit incur penalties.

For non-compliant farmers, the penalty is applied across all EU funded Direct Payments schemes and land based Rural Development Programme/CAP Strategic Plan measures, i.e. including Basic Payment Basic Payment Scheme (BPS)/BISS and the Green Low-Carbon, Agri-environment Scheme (GLAS)/Agri-Climate Rural Environment Scheme (ACRES), where applicable. Penalties are increased for repeated non-compliance.

These sanctions are applied under the Terms and Conditions of the Direct Payment Schemes and Rural Development Programme/CAP Strategic Plan measures.

In 2023, the number of farmers penalised for exceeding the Nitrogen limits in 2022 was 2,808 in total across all farmers. Of that number, 569 exceeded the 250 kg limit and of these 156 were Nitrates Derogation herds. Each farmer is entitled to appeal any sanction imposed to the Agricultural Appeals Office. Work is still ongoing to identify all those who breached the limits in 2023 and this 2023 data will be reported at a later stage.

Table 5.3.2. Total number of penalties issued 2015-2022 across all farmers **(derogation and non-derogation applicants)** for breach of the 170 kg N/ha or 250kg N/ha limit.

Year	2015	2016	2017	2018	2019	2020	2021	2022
No. of penalties issued*	1,834	1,888	1,658	1,884	1,829	1,861	2,474	2,808*

Note* The figures reported for penalties are reported at a point in time and therefore could possibly change in future due to appeals etc.

The increase in penalties applicable for 2021 and 2022, compared to previous years coincided with the introduction of the online system for the recording and verification of movements of organic manures between holdings as well as stricter requirements for derogation farmers, including increased enforcement activity with effect from 2022.

In accordance with Article 11(3) if a derogation applicant is found to have failed to fulfil any of the conditions set down in Articles 6-9 of the Commission Implementing Decision, or the Terms and Conditions of the Nitrates Derogation for the year in question, then in accordance with Ireland's national rules that applicant is not eligible to benefit from the derogation for the year in question. They are then subject to the 170kg N/ha stocking rate limit applicable to non-derogation farmers. In addition, in accordance with Article 11(3), that applicant is not eligible to apply for a derogation the following year.

5.4. Field inspections

Derogation Decision – Reporting Requirements Article 13(i) a comparative analysis of controls of grassland farms in Ireland covered by authorisations and grassland farms in Ireland not covered by authorisations. The analysis shall include data on annual inspections, administrative checks, agricultural inspections in the context of cross-compliance arrangements and statistics on non-compliance.

As outlined above, DAFM's administrative controls in respect of all applications are complemented by a programme of audits and inspections at farm level which are risk based to ensure the requirements set out in the Commission Implementing Decision are effectively complied with and enforced. Audits involve detailed field inspections combined with on-the-spot administrative checks to verify compliance with Articles 6 to 9 of the Commission Implementing Decision as well as appropriate aspects of the Terms and Conditions applicable to derogation applicants for the year in question. Additionally, a number of field inspections are conducted on derogation holdings targeted to the risk and to the level of compliance expected in the relevant situation. These usually take place in Quarter 1 of the year focussing on the farmyard at the time of year when non-compliance is most likely to be identified, however nominated inspections under Statutory Management Requirement (SMR) 2 of the CAP Strategic Plan may take place at any time following cross reports by an officer on another type of inspection or arising from complaints made by the public.

5.4.1. Selection Criteria

Applicants are selected for audit/inspection in a number of ways including risk analysis, random selection, and potentially, under a nomination. Herd numbers can be nominated for an audit/inspection if, for example there is suspected to be in breach of the Regulations following a cross report by an officer on another type of inspection or receipt of a complaint from a member of the public.

20% of the total applicants selected for inspection are selected on a random basis. Following this, the remaining cohort of applicants are selected by taking into account the highest associated 'risk' for each applicant that may result in that applicant incurring a breach of the Nitrates Regulations. Examples of the risks used to select these applicants include *inter alia*; herd numbers receiving nitrates penalties in the previous 3 years, herd numbers that were not subject to nitrates or cross-compliance inspection in previous 3 years, herd numbers with a stocking rate increase of 30kgs N/ha or more compared to the previous year or herd numbers with lands bounding a watercourse. The risk analysis process is reviewed each year and it is evolving in light of Ireland's experience.

A total of 750 audits/farm inspections were carried out by DAFM on holdings that applied for a Nitrates Derogation in 2023. This complies with the minimum of a 10% inspection requirement in 2023. While the ground inspection part of the audits has taken place, the administrative aspect involving checks on fertiliser and other records has not yet been fully finalised for some of these cases. Therefore, a final figure on herd owners who will incur penalties and a breakdown of these penalties applicable will be reported at a later stage along with a comparative analysis of the outcome of controls applied to derogation farms compared to the outcome of controls applied to non-derogation farms in 2023.

Table 5.4.1 Breakdown of the field controls (audits/inspections) completed for holdings that applied for a derogation in 2023.

Field Control conducted	**Number of derogation herds subject to this control in 2023**
Nitrates Derogation/SMR 2 Audit	681
Nitrates Regulations Inspection	69
Total field based controls	750

Arising from the controls outlined in Table 5.4.1, a total of 113 cases of non-compliance have been identified to date (28/06/24). As outlined above, some of these checks are on-going. Full details for 2023 will be provided when the checks have been fully completed.

6. Overview of Methodologies, Monitoring and Results of the impact of the derogation granted in this Decision on water quality, as referred to in Article 10(2), 10(3) and Article 13 (b), (c) and (d)

6.1. Derogation Decision – Reporting Requirements in Article 13:

(b) the results of ground and surface water monitoring as regards nitrate and phosphorus concentrations, including information on water trends, both under derogation and non-derogation conditions as well as the impact of the derogation granted in this Decision on water quality, as referred to in Article 10(2);

(c) the results of soil monitoring as regards nitrogen and phosphorus concentrations in soil water and as regards mineral nitrogen in soil profile, both under derogation and non-derogation conditions, as referred to in Article 10(2);

(d) a summary and an evaluation of data obtained from the reinforced water monitoring referred to in Article 10(4), The EPA ***Water quality monitoring report on nitrogen and phosphorus concentrations in Irish waters 2023*** will be provided by the EPA as a separate attachment. **See Appendix 5.**

6.2. Derogation Decision-Two-year review:

In addition to the reporting requirements described in Article 13, Article 12(1) of the Implementing Decision sets out the requirement to submit, corresponding to the year 2023, an annex containing the results of monitoring as regards the nitrates concentrations of groundwater and surface waters and the trophic status of surface water bodies, based on the monitoring network and requirements of the Nitrates Directive 91/676/EEC and including at least maps showing those areas draining into waters where monitoring data reveal

(a) average values of nitrate concentrations above 50 mg/l or increasing trends of nitrates concentration compared to 2022;

(b) 'Eutrophic' status or 'could become eutrophic' status with a stable or worsening trend compared to 2022.

This is provided as an Annex within the EPA Water Quality Monitoring Report on Nitrogen and Phosphorus Concentrations in Irish Waters 2023. See separate attachment, Appendix 7.

6.3. Monitoring Programme

EU Member States are required to monitor the effectiveness of their Nitrates Regulations, under Article 5(6) of the EU Nitrates Directive. Ireland has been monitoring the effectiveness of the NAP measures since 2008 in part through the Teagasc delivered Agricultural Catchments Programme (ACP), funded by DAFM. The fourth cycle of the ACP was approved in November 2019 for a further four-year period to 31st December 2023, a cost of €2.5m per annum.

6.4. The Agricultural Catchments Programme (ACP)

Ireland's ACP was established in 2008 to:

i) monitor the effectiveness of the Good Agricultural Practice measures, initially for compliance with the Nitrates Directive (ND) and since 2014 with the Water Framework Directives (WFD),

ii) provide a scientific basis for policy review and,

iii) monitor the impacts of the Nitrates Derogation in Ireland.

The programme is a collaboration with over 300 farmers in six small river catchments in Ireland and has taken a whole catchment approach. By using the "nutrient transfer continuum" (Haygarth *et al.*, 2005) as a conceptual framework an extensive monitoring programme of nutrient sources and hydro-chemo-metrics have been designed similarly across all six catchments (Figure 6.4.1) to understand how nutrients are lost from agricultural sources, how they can be mobilised and transferred via different hydrological pathways, how they are delivered to water and where there may be a negative impact on water quality and aquatic ecology. The whole catchment approach was agreed upon during the first phase of the programme by the ACP Expert Steering Group composed of internationally leading scientists and national policy makers. This unique world-class database has provided great potential for investigating the dynamics of Nitrogen, Phosphorus, and sediment losses, as well as the processes involved (nutrient delivery and mobilisation). This programme is one of a kind in the world and Ireland is one of very few countries have access to this world-class data.

Although long-term monitoring has been conducted in few Scandinavian countries (e.g. Sweden) from the 1980s, their data only captures flow weighted average concentrations based on bi-weekly data collection. The historical data (collected from the start of the ACP) gives a great picture of what has happened in the past, and the ongoing data collection enables monitoring of the impact of water protection actions. This has also enabled the programme to study the trends of nutrients not only across years, but also over months in different years so the risk on missing an event or data being skewed is minimised.

The high temporal resolution of ACP's data enables the programme to detect any slight changes in the concentrations of nutrients and sediments, and hence enable development of solid scientific knowledge on the processes involved, building of decision support tools for managing nutrients, and identification of appropriate mitigation strategies, all in view of climate change.

Numerous technical methods and models have been developed within ACP and although the typologies of ACP catchments are not representative of the diverse landscapes in Ireland, they still provide vitally important and extremely helpful information of the differences in the sensitivity of catchments to the changing weather patterns and anthropogenic activities.

This is particularly important considering the increasing occurrence of extreme hydrological events (climate change) as there is a knowledge gap of how/to what extent the weather would impact water quality in different catchments and what would be the most efficient climate-resilient measure in different regions. Such information can also be of great value for Ireland's Climate Action Plan for a Cleaner Water as ACP study results are scientific, robust, and thorough.

Key Messages arising from the Agricultural Catchments Programme

- The Agricultural Catchments Programme is building a robust scientific understanding of the factors affecting nutrient loss.
- Ireland's landscape is heterogeneous in terms of factors controlling N and P transfer pathways, transformation processes and timing of delivery.
- The influence of soil type, subsoil and geology on nutrient loss to water can override source pressures. At the small-scale catchment (*ca.* 10 km2) the link between nutrients source pressures and nutrients monitored in the stream water was not clear.
- Weather changes can override temporal trends of agronomic pressures.
- Extreme hydrological events (heavy rainfall and drought) have a direct impact on nutrients (N & P) concentrations leaving the catchments.
- Nutrient concentrations are driven by temperature, soil moisture deficit, and rain, and controlled by soil chemistry and drainage.
- While increases in the river flow contributes to an increase in both N & P losses, flushes of P into the waterbodies are more associated with heavy rainfall whereas prolonged high air/soil temperature followed by heavy rainfall are dominant driving factors of N losses.
- The influences of weather shifts were different for different physical settings. Both long-term weather shifts and short-term offsets need consideration.
- To assess inter-annual trends requires a minimum four years of data.
- There were increasing inter-seasonal trends in the climatic drivers of nutrient and sediment losses [i.e. increasing temperature and more frequent occurrence of heavy rainfall (prolonged dry/wet period] during the monitoring period.
- Sediment can have a greater impact on key indicators of water quality than N and P.
- Site specific information is required to implement appropriate measures.
- In order to offset the impact of extreme weather events, climate smart measures are needed that are tailored to different catchment typologies.
- Measures need time to be implemented on farms to deliver a positive impact on water quality.
- The ACP recently started to monitor N and P concentrations in soil solutions and groundwater on derogation and non-derogation farms.
- The ACP is combining monitoring of water quality, greenhouse gases, ammonia, soil C sequestration and socio economy all in one programme, in order to facilitate sustainable farming practices.
- The ACP is using high temporal resolution water quality data from small-scale catchments together with spatially high resolution data from the national data to scale-up to regional and

Methodologies reflecting Irish Conditions

Given the unique typology and geographical circumstances and primarily grass based system of production, Ireland has implemented a "Whole Catchment Approach" to water monitoring as regards nitrate concentrations, including information on water trends, both under derogation and non-derogation conditions as well as the impact of the derogation granted in this decision on water quality, as referred to in Article 10(2) of the Commission Implementing Decision granting Ireland's Nitrates Derogation 2022-2025. While Article 10(2) specifies the requirement to report the results of ground and surface water monitoring, Ireland considers from a scientific perspective the approach adopted at a Catchment level reflects the true scientific reporting on water quality. This is due to Ireland's multi facet soil type which does not reflect the homogenous nature of soil type in other EU Member States.

The approach adopted "Whole catchments approach"

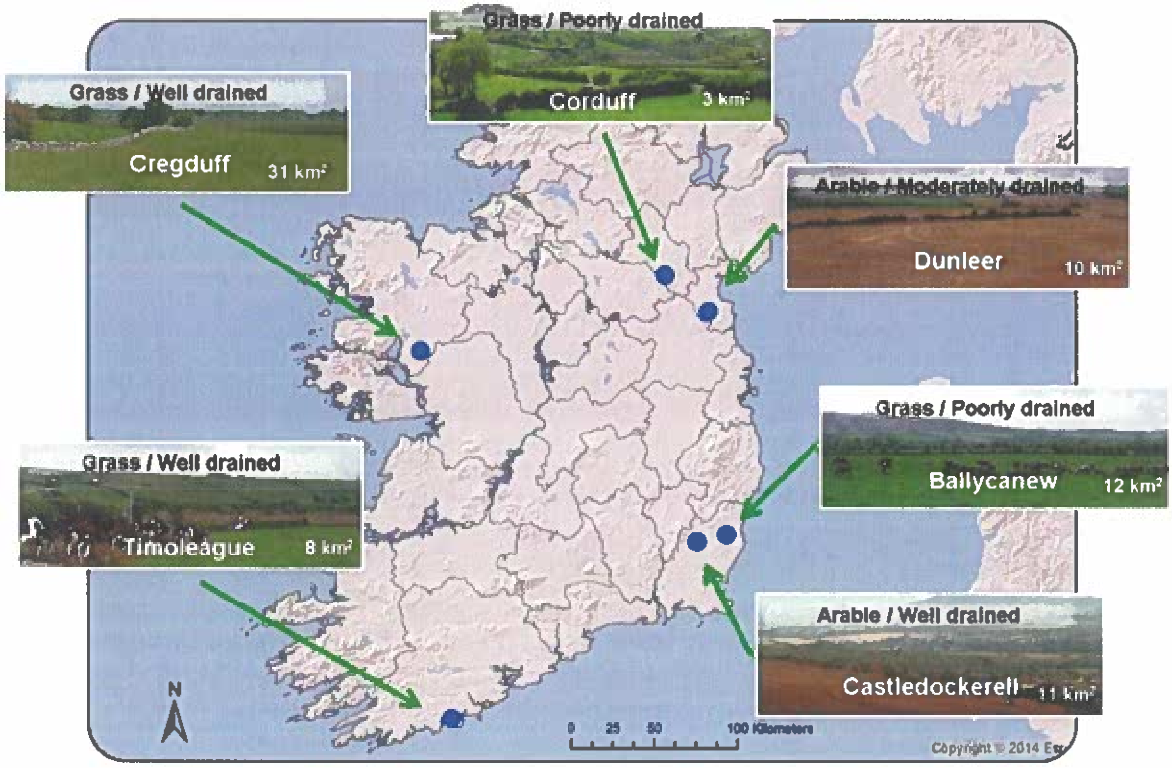
The ACP consists of six catchments ranging in size from $3km^2$ to $30km^2$. These have been continually monitored since 2008 and were selected by a multi-criteria analysis (Fealy *et al.*, 2010) to represent intensively managed agricultural land on different physical settings and dominating land use, therefore different types of risk for N and P loss in terms of vertical drainage or lateral runoff risk (**Figure 6.4.1 and Table 6.4.1**). Since both surface and groundwater bodies are deemed to be at risk for N and P transfers in Ireland, the catchment scale was chosen to include monitoring of surface and groundwater. Catchments allow monitoring of hydrologically isolated source areas which is suitable since the WFD operates on the scale of catchments and a catchment evaluation was also directed for Ireland by EU legislation (OJEC, 2007). The catchment size was further chosen to be large enough to encompass the range of hydrological conditions from headwaters to main river channel, allowing for normal N and P transformation and mobilisation processes to occur, and also to integrate the impacts of a realistic range of farm practices within a typical farming system (Wall *et al.*, 2011). Importantly the size was also chosen to be small enough to engage with all farmers in each catchment.

The biophysical and socio-economic data collection started in 2009 and includes:

- **Surface water** in the catchment river outlets: river discharge (Q), Electrical Conductivity (EC), Temperature, Turbidity and nitrate-N, Total Reactive P (TRP), Total P (TP) and Total Organic Carbon (TOC, since 2018) concentrations (every 10-minutes)
- **Surface water** in multiple sites along the river networks: nitrate-N, TP, Total Dissolved P (TDP), TRP, Dissolved Reactive P (DRP), Dissolved Organic Carbon (DOC), EC, pH, Dissolved Oxygen (DO), Oxidation-Reduction Potential (ORP), Turbidity and metals (monthly)

- **Groundwater** in focused study sites: piezo-metric water level (every 30 minutes), and nitrate-N, TP, TDP, DRP, DOC, EC, pH, DO, ORP, Turbidity and metals sampled in multilevel monitoring wells (monthly)
- **Weather** data; a weather station is located centrally in each catchment, from which current data is publicly available at www.acpmet.ie: Air Temperature, Soil Temperature, Relative Humidity, Rain, Solar Radiation, Wind Speed/direction for estimation of Potential Evapotranspiration (PET) (every 10-minutes) and additionally rain at higher ground (every 10-minutes)
- **Aquatic ecology** in four to five sites along the river networks: diatoms and macroinvertebrates assessed (every May and September)
- **Soil** analysis at the field scale (every 4 years, maximum sampling unit 2ha, to 0-10cm depth): pH, liming requirement (LR), P, K, and Mg content
- **Land management data** supplied by DAFM is added to more detailed information collected by advisors and data recorders
- **Socio economical and attitudinal surveys** of catchment farms have been compared and supplemented with data from the National Farm Survey (NFS)
- Since 2022 the programme includes focused study sites of **soil solution** monitoring **on derogation** and **non-derogation farms**
- Since 2022 the programme includes monitoring of **greenhouse gas and carbon sequestration.**

Figure 6.4.1. The six catchments monitored within the Agricultural Catchments Programme.



Additionally, each catchment has been surveyed for soil type, topography (LiDAR <1m) and geology (EM3/EM37, 2-D resistivity, seismic refraction and GPR on representative fields).

Knowledge exchange occurs frequently *via* the specialised farm advisors either one-to-one or in discussion groups. There are also public events and farm walks arranged, and research dissemination events are held annually.

A decade of studies within the ACP was summarised in a review paper siting 67 research papers by the ACP published in international journals (Mellander *et al.*, 2022).

Table 6.4.1. Dominating catchments characteristics, annual average stocking rate (organic N load 2010-2018), organic P load in 2008-2014 and in 2022, annual average rainfall, river flow, and nutrient mass loads in the river (2010-2023), and average input and output loads in 2022.

Catchments characteristics				Annual inputs			Annual outputs 2010-2023			
Name	**Land use**	**Soil drainage**	**Size**	**Rain fall**	**Stocking Org P** 2008-2014	**Stocking Org N** 2010-2018	**River flow**	**TRP** 2010-2023	**TP** 2010-2023	**NO_3-N** 2010-2023
			[km^2]	[mm]	[kg ha^{-1}]		[mm]	[kg ha^{-1}]		
Corduff	Grass	Poor	3	1031	12	87	684	0.24	0.57	11.6
Dunleer	Arable/ Grass	Moderate	10	860	9	67	429	0.5	1	22.7
Ballycanew	Grass	Poor	12	1034	11	101	558	0.6	1.2	13.3
Castledockerel	Arable	Well	11	1008	4	41	573	0.11	0.34	33.4*
Timoleague	Grass	Well	8	1091	23	166	716	0.5	0.87	40
Cregduff	Grass	Well	31	1191	10	90	170*	0.02	0.03	1.98*

*Data missing

Catchments	Annual inputs in 2022		Average outputs in 2022		
	Stocking Org P	**Stocking Org N**	**TRP**	**TP**	**NO_3-N**
	[kg ha^{-1}]		[kg ha^{-1}]		
Corduff	16.4	113.8	0.4	0.97	16.4
Dunleer	14.6	94.6	0.52	0.9	23.7
Ballycanew	20.3	142.6	0.64	1.17	16.5
Castledockerell	9.8	81.2	0.04	0.1	11
Timoleague	23.7	169.5	0.35	0.54	33
Cregduff	14.4	98.5	*	*	1

Comparing the Catchment Scale Approach in average annual loads of nutrients

The annual total organic N loading has clearly increased in the *Timoleague* catchment, which had the highest stocking rate throughout the period (Table 6.4.1). Based on DAFM data received for 2022, *Timoleague* had 56.7% of the land in derogation in 2022 while it was 54% from 2010-2018. There has been a decrease in stocking rate in *Ballycanew* with an average of 20.6% of the land in derogation [on average, it was 30% in 2018]. The lowest % of derogation was in the *Cregduff* and *Castledockerell* catchments where only 2% and 4% of the land was in derogation in 2022, respectively. The stocking rate in *Castledockerell* was the lowest in 2022.

Fourteen-years of high frequency monitoring of N and P concentration in the catchment's outlets showed that not only the magnitudes of concentrations but also the dynamics varied across the catchments (Figure 6.4.2). The link between the percentage of land in derogation and the stream water concentration of nitrate-N was not clear for stocking rates below 250 kg N/ha, reflecting differences in soil type, land-use and meteorological factors which were evident at the catchment scale of the ACP. The physical setting overrides the source pressure (Jordan *et al.*, 2012; Mellander *et al.*, 2012a; Shore *et al.*, 2016). Despite catchments having similar organic N and P loading (Table 6.4.1) the water quality, in terms of N and P concentration, was very different in the catchment outlets (Table 6.4.2).

There was a large difference in loss of nutrients to water due to soil drainage (Jordan *et al.*, 2012). Despite similar source loading the *Ballycanew* catchment with poorly drained soils and a "flashy hydrology" had three times higher total P loss than the well-drained and mostly groundwater fed *Castledockerell* catchment (Figure 6.4.3) (Mellander *et al.*, 2015). However, also catchments with similar soil drainage can differ in nutrient loss due to processes associated to the soil chemistry as a controlling factor for P solubility.

In the *Timoleague* catchment with iron rich soils there was more P loss to the stream *via* leaching to shallow groundwater (Mellander *et al.*, 2016; Dupas *et al.*, 2017). Iron rich soils have also been found to increase the loss of medium sized colloidal P (Fresne *et al.*, 2020). In another free draining catchment with calcium rich soils P was instead largely retained (Mellander *et al.*, 2012b; Mellander *et al.*, 2013).
The research so far has highlighted the overriding importance of soil type, drainage status, subsoil, geology, and groundwater hydrochemistry in controlling N and P loss to water.

Figure 6.4.2. ***Nitrate-N concentration levels and dynamics vary within the different catchment rivers.*** Monthly average (antecedent moving average) nitrate-N concentrations at daily time steps in the catchment's river outlets monitored within ACP (2010-2023). The Water Framework Directive estuarine Environmental Quality Standard nitrate-N concentration 2.6 mg l^{-1} is marked as dashed line. Stocking rate as annual total organic N per hectare in the whole catchments (2009-2021) is represented by a red dotted line. The timing for the five NAP's (National Action Plans) are marked as arrows in the bottom of the figure.

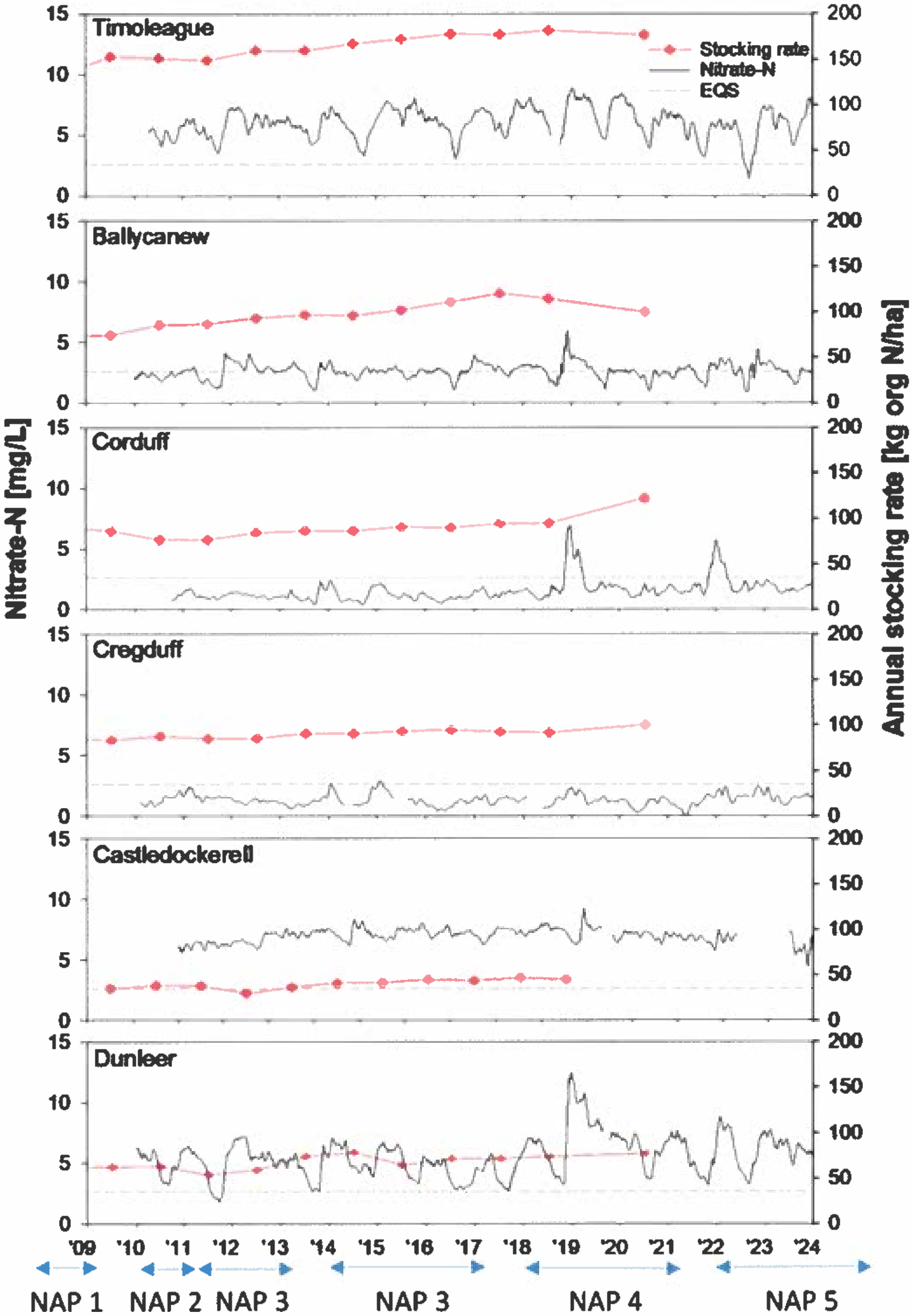


Figure 6.4.3. ***In some catchments hydrology overrides source pressure.*** Monthly Total P mass load as a function of river flow in two catchments with contrasting soil drainage and hydrology but with similar P source loadings (from Mellander *et al.*, 2015).

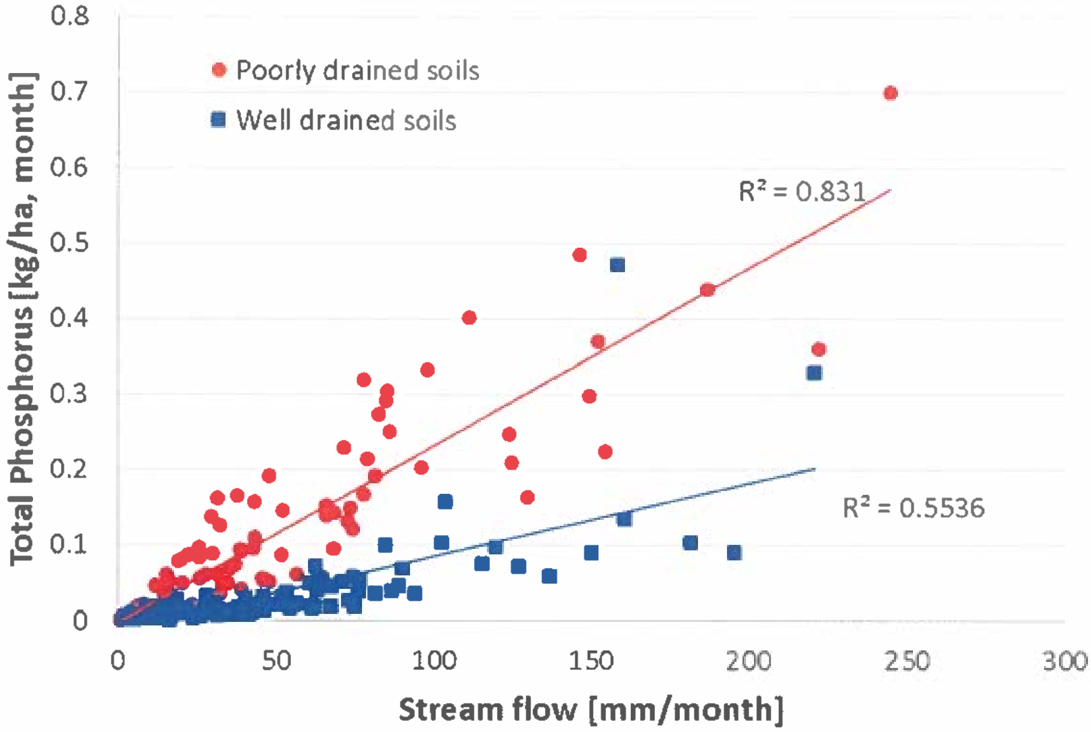


Table 6.4.2. Average nutrient concentration in the rivers of the catchments outlets of the six catchments and inter-annual trend (Mann-Kendal method) for the period 2010 - 2023.

↑ = increasing trend in the concentration, ↓ = decreasing trend in the concentration, → = stable (no change), -- = no trend for concentrations. The number of arrows shows the significance level of the trends, with more arrows meaning a higher significance level. The colour coded indicates ecological status: MRP concentrations of <0.025 mg/l as high status (blue) and <0.035 mg/l as good (green).

NO3-N was converted to NO3 by multiplying by 4.43.

Annual average concentration				
Name	TRP [mg l⁻¹]	TP [mg l⁻¹]	NO_3-N [mg l⁻¹]	NO_3 [mg l⁻¹]
Corduff	0.035 ↑↑	0.0581 ↑↑	1.53 ↑↑	6.77
Dunleer	0.133 ↑	0.181 ↑	5.51 ↑	24.41
Ballycanew	0.081 ↑	0.121 ↑	2.59 --	11.47
Castledockerell	0.028 →	0.048 →	6.94 --	30.74
Timoleague	0.069 ↑	0.107 ↑↑	5.97 --	25.64
Cregduff	0.017 →	0.023 --	1.34 --	5.93

The driving and regulating factors of nutrient losses (groundwater and surface water)

The Irish agricultural landscape is heterogeneous in terms of its physical setting and even within smaller catchments (*ca.* 10km2), such as those monitored within the ACP, there can be a large variability in soil types and the factors controlling how both N and P transfer can transform in the landscape (such as topography, soil and bedrock properties – mainly permeability).

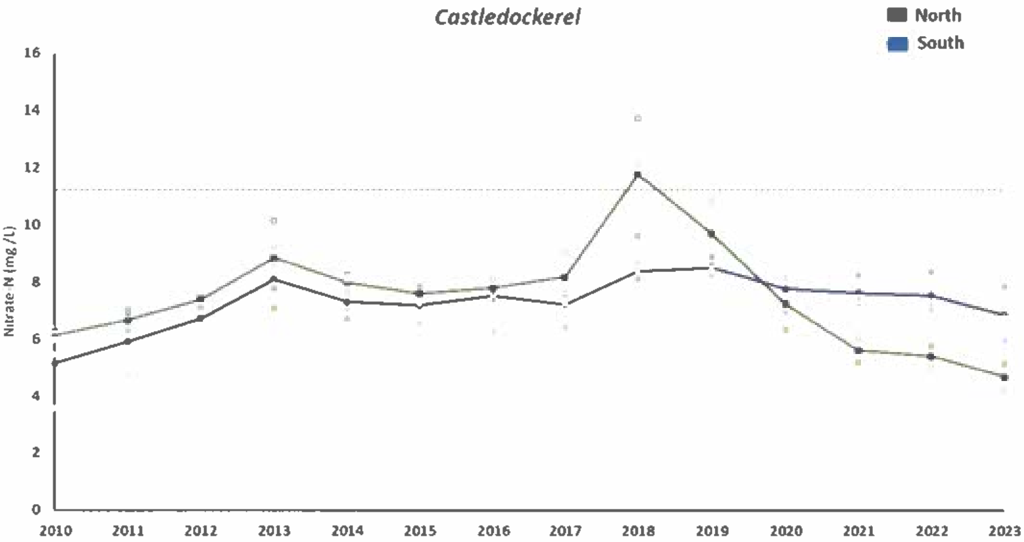
Leaching of N is not a steady state process and there are many factors controlling nitrate-transport and transformation in the unsaturated zone (Fenton *et al.*, 2011; Jahangir *et al.*, 2012). Such factors include both static (e.g., soil and bedrock type, thickness and permeability) and dynamic factors (e.g., climate, soil moisture deficit, depth to water table) which are spatially and temporally variable across any farming landscape (Huebsch *et al.*, 2015; Mellander *et al.*, 2018; Fenton *et al.*, 2017) and will influence the nitrate-N concentrations both spatially and temporarily (Figure 6.4.4).

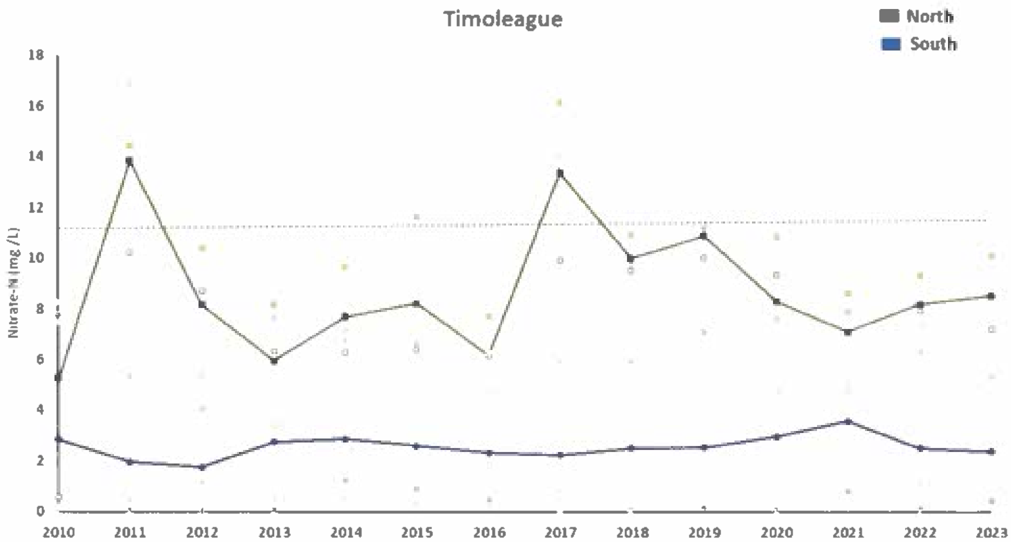
The N removal capacity varied highly between and within two of the catchments monitored within the ACP (McAleer *et al.*, 2017). At the catchment scale there was a poor link with the surplus nitrate-N leached to the groundwater and the concentrations of nitrate-N monitored in the catchment river outlet. For example, in one of the catchment monitoring sites the nitrate-N concentration in the shallow groundwater locally reached highly elevated levels of 23.9 mg/L as the result of a ploughing and pasture reseeding event. This was however not detected in the river due to the locally high N removal capacity and likely also due to mixing of deeper groundwater with lower nitrate-N concentrations (Mellander *et al.*, 2014). That catchment further had significantly lower nitrate-N concentrations than an intensively managed arable catchment on similar physical setting in Brittany (Dupas *et al.*, 2017).

Therefore, a reduction in N surplus can enable N load transfer to groundwater to decrease over time leading to improvements in water quality in some areas after hydrological and biogeochemical time lags are considered, (*e.g.,* nitrate improvements in free draining soils and ammonium improvements in poorly drained soils). In heavier textured soils emissions along other pathways (e.g., gaseous emissions) must also be considered and conversion of nitrate to ammonium which can be lost to surface water along intercepting artificial drainage systems.

For groundwater, an expected improvement in water quality as the results of mitigation measures may be delayed due to variable drainage amounts and delayed responses of nitrate in deep aquifers (Fenton *et al.,* 2011). In meso-scale catchments a positive response occurred from 1 to 10 years after decreased N surpluses were achieved, with the response time broadly increasing with catchment size (Melland *et al.* 2018). However, it took from 4 to 20 years to confidently detect the effects in water body monitoring systems. Such time lag may be a useful indicator to reveal the hydrogeological links between the agricultural pressure and water quality state, which is fundamental for a successful implementation of any water protection plans (Kim *et al.*, 2020).

Figure 6.4.4. ***Nitrate-N concentrations in groundwater.*** Average nitrate-N concentrations per year in shallow near-stream groundwater in three locations each (North with green colour and South with blue colour) in two mostly groundwater fed catchments (*Timoleague* and *Castledockerell*) for the period 2010 – 2023. The straight line shows the annual average between locations. The European Drinking Water Standard of 11.3 mg N/L is marked with a dashed line.



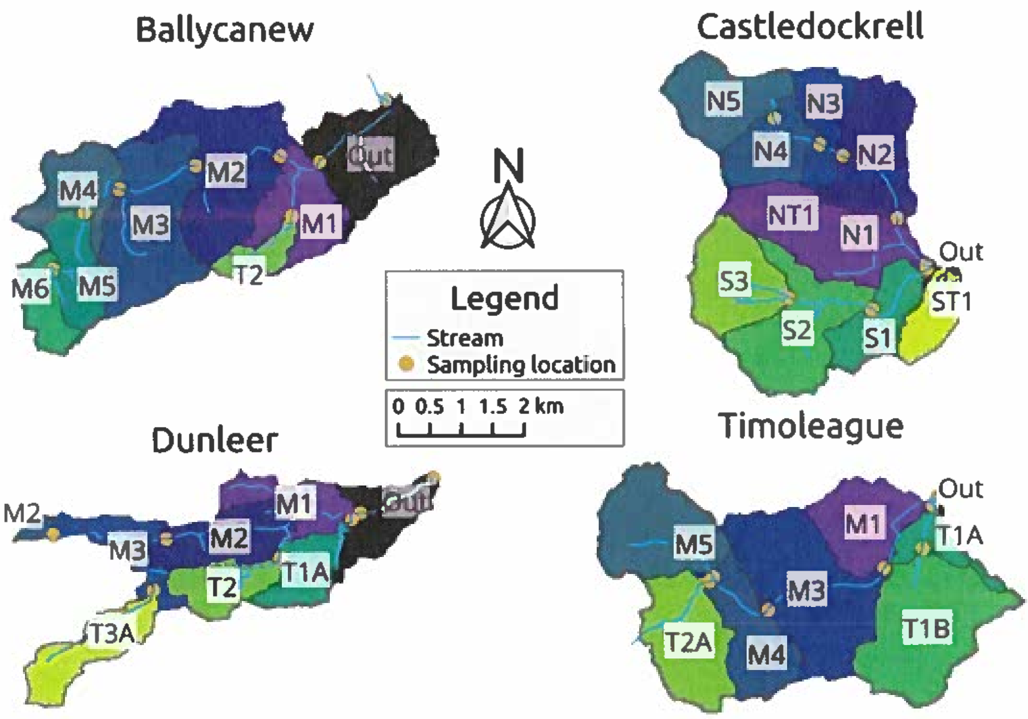


Sub-catchments approach: Impacts of meteorology and agronomy on water quality trends

The ACP catchments are located in intensively managed agricultural areas, and N inputs from farming are likely to account for the vast majority of nitrate in the catchment outlets. However, a poor relationship between source loading and stream water nitrate was observed as changes in source loading only explained *ca*. 2% of the variation in stream water nitrate-N concentration (Galloway *et al*., in review). In addition, soil drainage controls the fraction of N that can be leached, how quickly it reaches the stream water, and the proportion of N that is removed naturally. Therefore the measured stream water NO_3-N concentrations are the results of several complex and interacting processes.

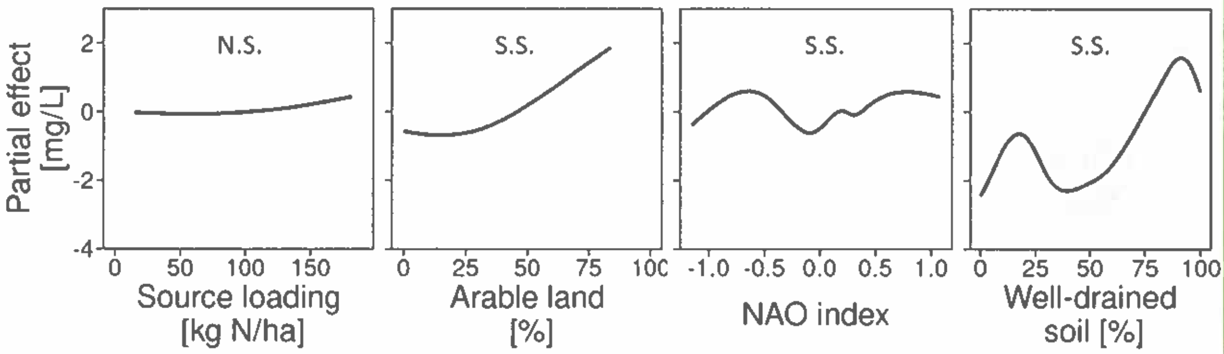
In order to understand the importance of this, the ACP has adopted a *sub-catchment* approach where four catchments were divided into 7-10 nested (*ca.* 1km^2) sub-catchments (Figure 6.4.5, Galloway *et al*, in review). Each of these smaller sub-catchment had different characteristics which allowed the relationships between explanatory variables such as nutrient source load, land use, climate, soil drainage and the stream nitrate-N concentrations to be assessed. In order to capture any complex relationships, within each catchment and across all catchments, a systematic statistical approach using generalized additive mixed models was used.

Figure 6.4.5. *Maps showing the four catchments divided into sub-catchments*. The locations of monthly stream sampling are denoted by yellow circles, these locations were used to determine the topological-driven drainage area for each sampling point. From Galloway *et al.* (in review).



The results showed that there was no clear relationship between source N loadings and stream nitrate-N concentrations. A likely explanation could be that the N cycling in the study sites were not source-limited, therefore, processes which control the movement of N from fields to streams have a more direct link to stream water nitrate concentrations. There was, however, a statistically significant relationship between the climate and hydrological characteristics of catchments (Figure 6.4.6). Since the site-specific characteristics would mediate the significance of the drivers of N losses, effective mitigation measurements should consider hydraulic properties (e.g. soil drainage).

Figure 6.4.6. *The partial effect shows how changes in an explanatory variable impact stream water nitrate-N concentrations.* Partial dependence plots for source N loading, the percentage of arable land, the North Atlantic Oscillation (NAO) index and the percentage of well-drained soil within a sub-catchment. Results are shown for all sub-catchments aggregated. Light-grey shading indicates the 95% confidence interval around the partial dependence (solid black line). Statistically significant relationships are denoted by (S.S.) and non-statistically significant relationships are denoted by (N.S.). From Galloway *et al.* (in review).



Changes in rainfall intensity and soil temperature were found to be important drivers of nutrient mobility in soils (Mellander and Jordan, 2021). In 2018, a nation-wide drought caused a build-up of a large soil N pool which was flushed out and transferred to the stream during heavy rainfall events in November causing elevated nitrate-N concentrations (Mellander and Jordan, 2021). The influence of this weather extreme was clearly seen in the ACP catchments although different within each site. The monthly average nitrate-N concentrations increased in all catchments and in *Dunleer* catchment exceeded the WFD drinking water standard threshold of 11.3 mg l^{-1} (Figure 6.4.2). The daily average nitrate-N concentration also exceeded the WFD threshold in *Ballycanew* usually has a relatively low nitrate-N concentration. In *Timoleague*, there was a high annual organic N loading with an increase from 134 to 182 kg ha^{-1} (2008-2018) (Figure 6.4.2) but there was no statistically significant temporal trend in the groundwater nitrate-N concentration during 2010-2017 (McAleer *et al.*, 2022). In *Castledockerell*, there was a low annual organic N loading with a minor increase from 35 to 45 kg ha^{-1} from 2008-2018, and there was a higher groundwater nitrate-N concentration with an upward trend during 2010-2017 (McAleer *et al.*, 2022). The study results showed that factors such as N application, soil moisture deficit and soil/bedrock permeability explained 60-80% ($P<0.0001$) of the nitrate occurrence in the groundwater suggesting that it was not possible to separate agronomic factors from meteorological ones. Despite having lower sources, *Castledockerell* had high nitrate-N concentrations in both groundwater and surface water due to a combination of free draining soils, lower drainage and tillage management practices (McAleer *et al.*, 2022).

<u>Dynamics of Nutrient Concentration and the impact of climate and extreme hydrological events on them</u>

It is scientifically well established that widespread and long-term shifts in weather patterns are contributing to further degradation of surface water quality (Strohmenger *et al.*, 2020; IPCC, 2022). This challenge caused by the increasing frequency of extreme weather events (drought, storm, heavy rainfall) requires appropriate adaptation of current mitigation strategies. In view of this, and to confirm the need to redesign such strategies, an understanding of the impacts of increasing weather extremes on pollutant losses in different catchment types is required. This is due to the fact that different catchment typologies have shown to react differently in terms of losses and water pollutants. Few studies within the ACP have been conducted to understand the trends of nutrient losses, and the transfer/mobilisation processes involved, considering the changing weather patterns (Ezzati *et al.*, under-review; Mellander et al. under review; Ezzati *et al.*, submitted). The significance of water discharge, precipitation, potential evapotranspiration, soil moisture deficit, air temperature, and soil temperature on the losses of nutrients have been investigated using Mann-Kendall Trend Analysis and Generalised Additive Models.

- **Trend analysis of nutrients and climatic drivers**

Not all increasing or decreasing patterns in water quality datasets are trends. Autocorrelation, seasonal patterns or return to normal conditions after an extreme event, such as a period of drought or flood, can lead to changes in data which are not trends (Meals *et al.* 2011). The longer the time series of data, the less likely it is to misidentify trends (or being unable to confidently identify trends which are present). It has been recommended to use as long of a time series as possible (Helsel *et al.* 2020; Meals *et al.* 2011; Yue, Pilon, and Cavadias 2002). In order to assess the impact of Best Management Practices (BMPs) the United States Environmental Protection Agency recommends using no less than four years of monthly measurements (2 years prior to and post intervention) (Meals *et al.* 2011). In terms of minimum requirements, the Mann-Kendall test (the standard method of trend analysis) requires at least four data points for viability. Within the ACP a four-year rolling Mann-Kendal inter-annual trend analysis was made on the 2010 – 2023 annual nitrate-N concentration (Table 6.4.3 & Figure 6.4.7). By applying the method on four-year rolling periods it was noted that it was sensitive to outlier years, such as the 2018 draught/flush-out event that largely Influenced the data presented in Table 6.4.3. For example, in the three catchments *Timoleague* (Grass), *Dunleer* (Arable and Grass) and *Corduff* (Grass) there was an increasing trend in nitrate-N concentration in the period that included 2018 in the end of the four-year period (period ending in 2019). In *Ballycanew* (Grass) and *Castledockerell* (Arable) there was instead a decreasing trend for periods including 2018 in the beginning of the period (periods ending 2020 - 2023).

Over 2019-2022, there was no trend in in *Ballycanew* and *Cregduff*, no change in *Dunleer* and *Corduff* and a decreasing trend in nitrate-N concentrations in the *Timoleague* catchment which reached its lowest annual average during the whole period of monitoring. However, in 2023, there has been a decrease in annual average nitrate-N concentration (mg/l) in all catchments except *Timoleague* (Figure 6.4.7). However, *Timoleague* and *Dunleer* showed obvious reduction in annual average TP concentration (mg/l) leaving the catchments. Total Phosphorus concentration increased in *Castledockerell* while it remained stable in *Cregduff* and *Corduff*, and showed a slight decrease in *Ballycanew* (Figure 6.4.8).

Table 6.4.3. Annual average nitrate-N concentration (mg/l) and the four-year Mann-Kendal inter-annual trends are indicated with symbols and colour coded: grey -- = no trend, blue → = stable (no change), red ↑ = increasing and green ↓ = decreasing.

Date	Ballycanew	Timoleague	Castledockerell	Dunleer	Corduff	Cregduff
2010	2.29	5.00	6.22	4.95	1.15	1.36
2011	2.34	5.39	6.48	4.48	1.17	1.65
2012	2.98	6.30	7.13	5.82	1.13	1.19
2013	2.56 --	5.64 --	7.21 ↑	4.57 →	1.20 --	1.14 →
2014	2.50 →	5.45 →	7.15 --	5.33 --	1.11 →	1.46 →
2015	2.53 →	7.07 →	7.37 --	5.22 →	1.25 --	1.61 --
2016	2.50 →	5.57 →	7.02 →	3.93 →	0.92 →	0.93 →
2017	2.91 --	6.49 →	7.42 →	4.40 →	1.35 --	1.34 →
2018	2.91 --	6.64 →	7.41 →	6.37 →	2.13	1.21 →
2019	2.73 →	7.15 ↑	7.22 →	8.44 ↑	2.30 ↑	1.39 --
2020	2.27 ↓	6.30 →	6.96 ↓	5.93 --	1.43 --	1.01 →
2021	2.48 →	5.43 →	6.66 ↓	5.51 →	2.20 →	1.05 →
2022	2.85 --	4.95↓	6.91 --	6.04 →	2.29 →	1.80 --
2023	2.55 --	6.24 →	* 6.03 →	6.27 --	1.75 --	1.47 --

* The figure for *Castledockerell* is modelled due to missing data during May 2022 to May 2023.

Figure 6.4.7. ***Thirteen years of annual average nitrate-N concentration*** **(symbols) and four-year antecedent moving average (line) in the six catchments monitored in the ACP.**

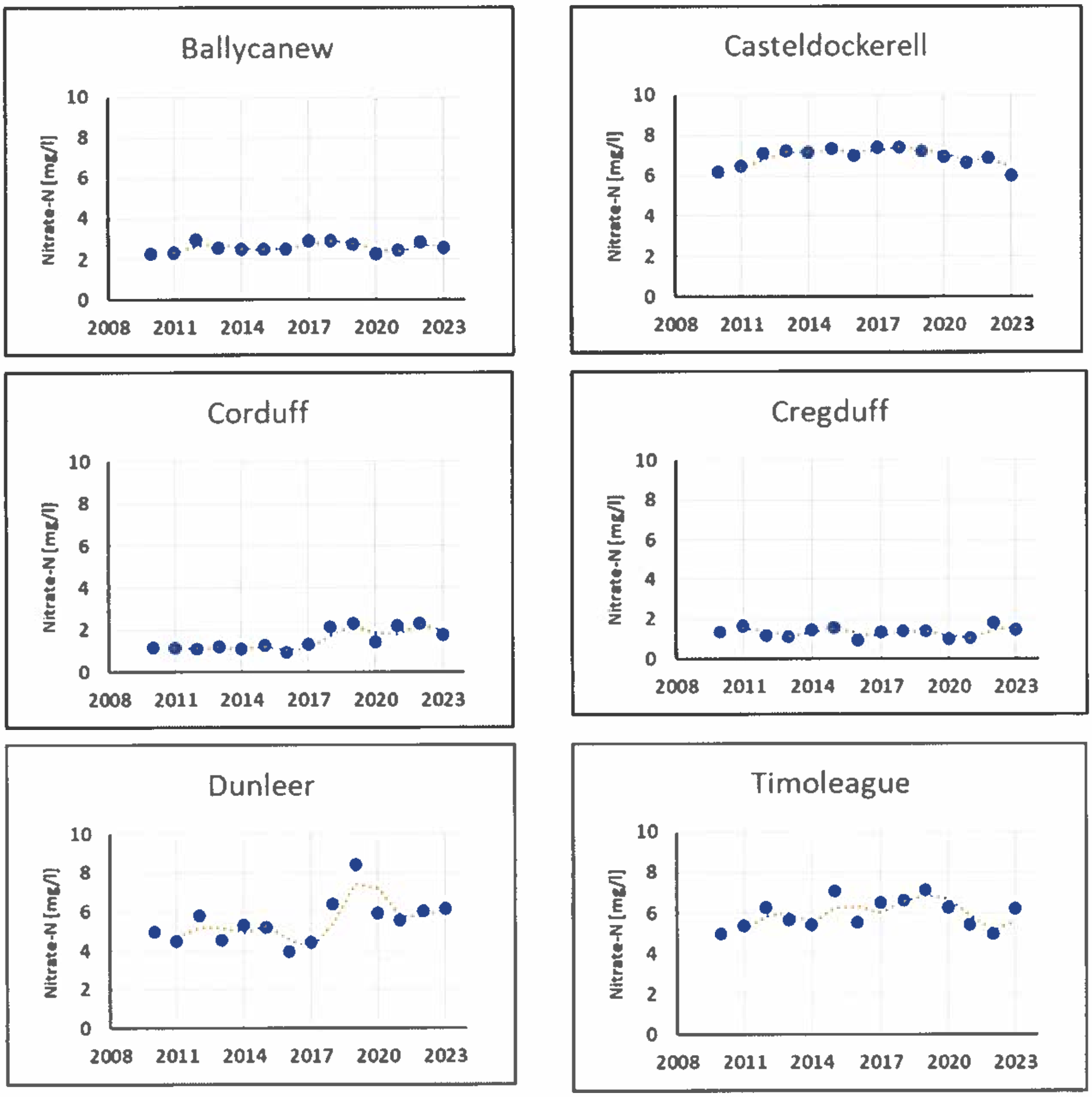
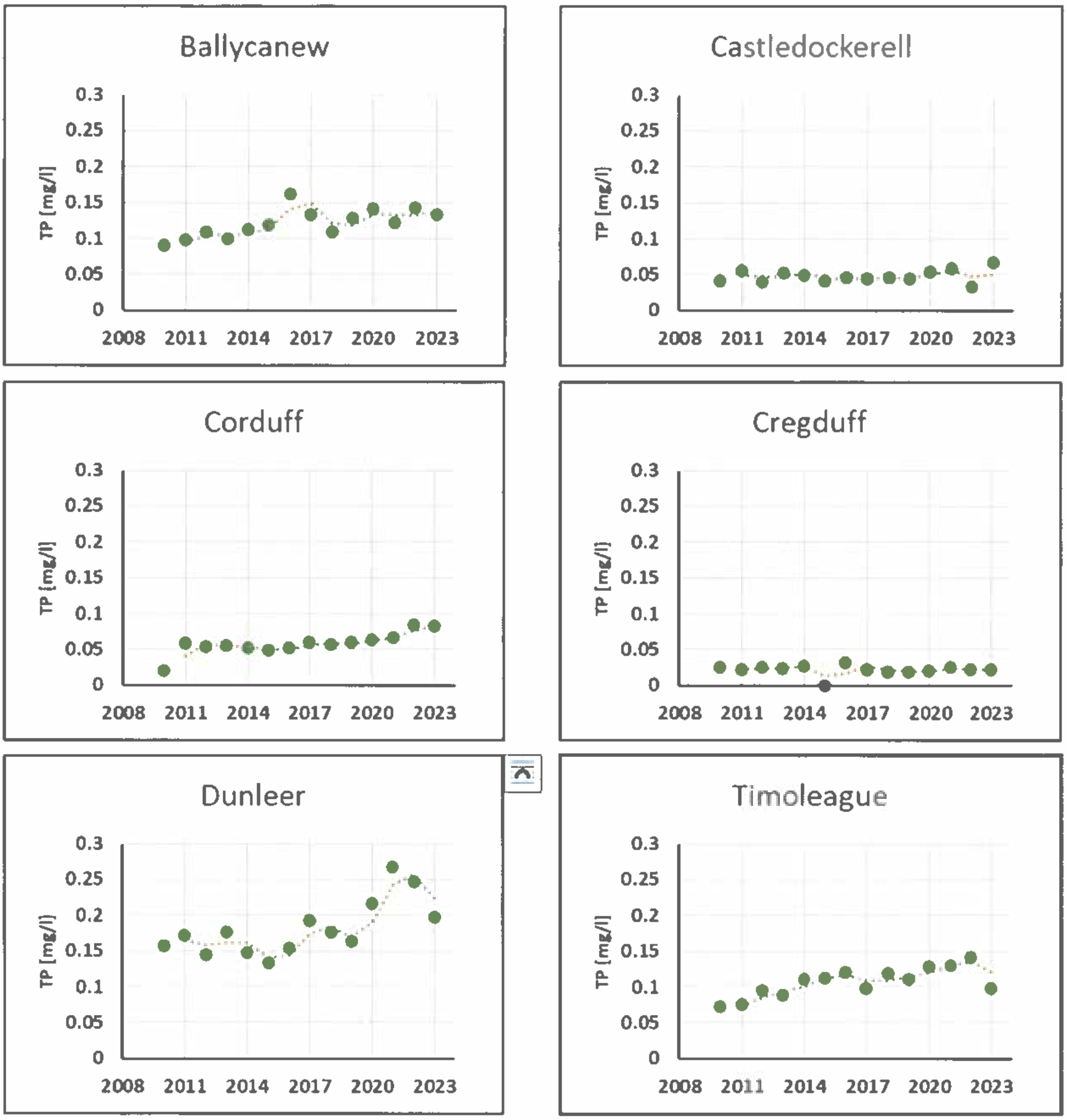
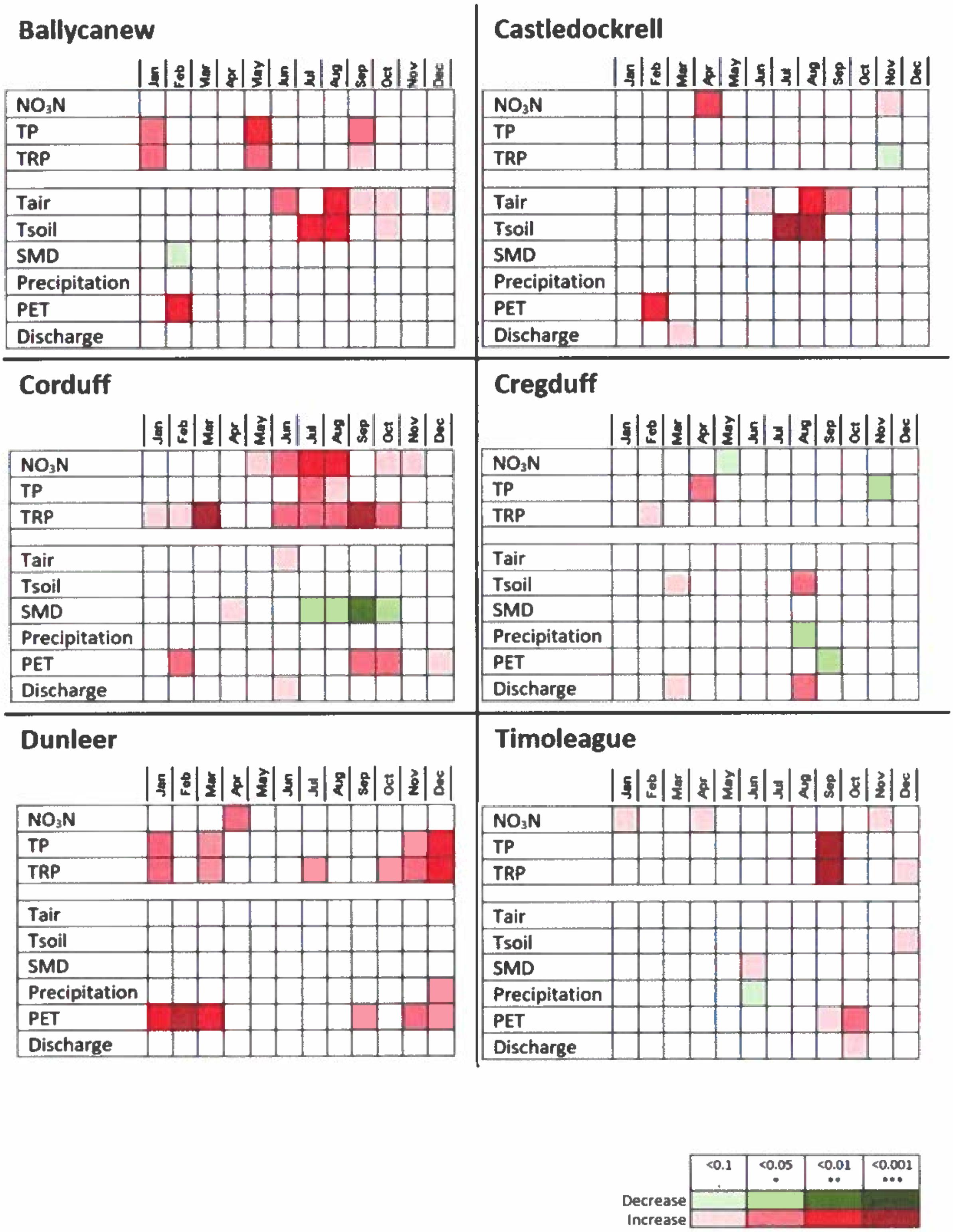


Figure 6.4.8. ***Thirteen years of annual average Total phosphorus (TP) concentration*** **(symbols) and moving average (line) in the six catchments monitored in the ACP.**



Ballycanew and *Corduff* (both being poorly drained) and the *Dunleer* (moderately-drained) had more frequently occurring monthly trend changes in the concentrations of NO_3-N and P compared to the other study catchments (Figure 6.4.9).

Figure 6.4.9. The average monthly trend analysis of NO_3-N, TP, TRP, and explanatory variables during 2010-2021 using Mann-Kendall tests. The red colour indicates increasing trends and the green colour indicates decreasing trends. The level of significance is presented by the different shades of any individual colour. (Ezzati *et al.*, under review)



The increase in monthly trends of nutrient losses in *Ballycanew* occurred during January, July, and September, while in *Dunleer*, the increase occurred during October-April. *Corduff* experienced an increase in monthly trend in nutrient losses throughout the year except in April and December. The trend showed more fluctuations in *Ballycanew* and *Corduff* compared to the other catchments. The air and soil temperature increased during summer in *Ballycanew* and *Castledockrell* and although they are geographically close, the changes in weather pattern were not identical.

There was a highly significant increase in TP and TRP concentrations leaving the *Timoleague* catchment during September; however, it does not coincide with a significant increase in the corresponding monthly trends of any of the climatic variables.

Corduff seemed to have more frequent changes in monthly trends in climatic drivers while *Dunleer* experienced significant changes in potential evapotranspiration during September-March. There were also overlaps of the changes in monthly trends in nutrient concentrations with monthly trends in climatic drivers in *Dunleer* (during January, March, November, and December).

- **Significance of climatic drivers in regulating nutrient losses**

None of the climatic drivers were significant in regulating NO_3-N losses during January-March, September, and December. Similarly, none of the drivers were significant in regulating TP/TRP concentration trends during April-May, and October, in any of the study catchments (Table 6.4.4 and 6.4.5). May-August and October-January were generally the time windows when significant changes in monthly trends occurred. Discharge (total volume of water flowing through the stream) appeared to be one of the main regulators of NO3-N losses during months in which, a significant increase of NO_3-N concentrations was observed. The significance of discharge occurred alongside its climatic drivers of Tair, Tsoil, and Precipitation. Tair was more associated with increases in NO_3-N and Precipitation with P. Summer time appeared to be the period in which most of the trend changes in the concentrations of both nutrients (Figure 6.4.4) and the drivers of concentrations including climatic drivers took place.

In terms of NO_3-N losses, *Corduff* was mostly influenced by climatic drivers followed by *Dunleer*, *Castledockrell*, and *Timoleague* (Table 6.4.4). In terms of P (TP and/or TRP) losses, *Dunleer* and *Corduff*, followed by *Timoleague* and *Ballycanew* exhibited more susceptibility to changes in weather patterns manifested in the 11 year long time series (Table 6.4.5).

Table 6.4.4. The significance of climatic drivers in regulating NO_3N concentrations with a significant monthly trend during water years spanning 2010-2021.

Catchments		Apr	May	Jun	Jul	Aug	Oct	Nov
Castledockrell	NO_3N	Discharge * Tair * SMD * Prcp ·						Discharge * SMD * Tair * Prcp ·
Corduff	NO_3N		Discharge * Precp ·	Discharge*** Prcp*** Tair*** Tsoil*** PET***	Discharge* Prcp** Tair** Tsoil** PET*	Tsoil ** Precp ·	Tsoil ** Tair * Discharge ·	Discharge ** Precp * Tair * PET *
Cregduff	NO_3N				Discharge · Prcp · Tair ·			
Dunleer	NO_3N	Discharge * Prcp * PET * Tair . Tsoil ·			Prcp * Tsoil * SS *			
Timoleague	NO_3N	Tair * Prcp ·						Discharge *

Prcp stands for Precipitation. The asterisks show the significance of each variable: $p \leq 0.001$ "***"; $p \leq 0.01$ "**"; $p \leq 0.05$ "*"; $p \leq 0,1$ "*" (Ezzati *et al.*, under review)

Table 6.4.5. The significance of climatic drivers in regulating TP and/or TRP concentrations with a significant monthly trend during water years spanning 2010-2021.

Catchments		Jan	Feb	Mar	Jun	Jul	Aug	Sep	Nov	Dec
Ballycanew	TRP							Tsoil ** SMD * Tair * Discharge ·		
	TP	Precp *						Tsoil * SMD · Discharge ·		
Corduff	TRP		Precp * Discharge · SS ·	SS *	Discharge* Precp * Tair * Tsoil ·	Tsoil * Tair ·	SS * Discharge · Precp ·			
	TP					Discharge* Tsoil * Tair *				
Cregduff	TRP		Tsoil · Tair ·							
	TP			Discharge*** Tair *** Tsoil** Precp *						
Dunleer	TRP			Precp ** Discharge* Tair · Tsoil ·					Precp ** Tair * Tsoil * Discharge * SS ·	Precp ·
	TP			Precp ** Discharge* Tair · Tsoil ·					Precp * Discharge ·	Precp * Discharge ·
Timoleague	TP	Discharge*** Precp *** SS ***						Precp * Discharge ·		

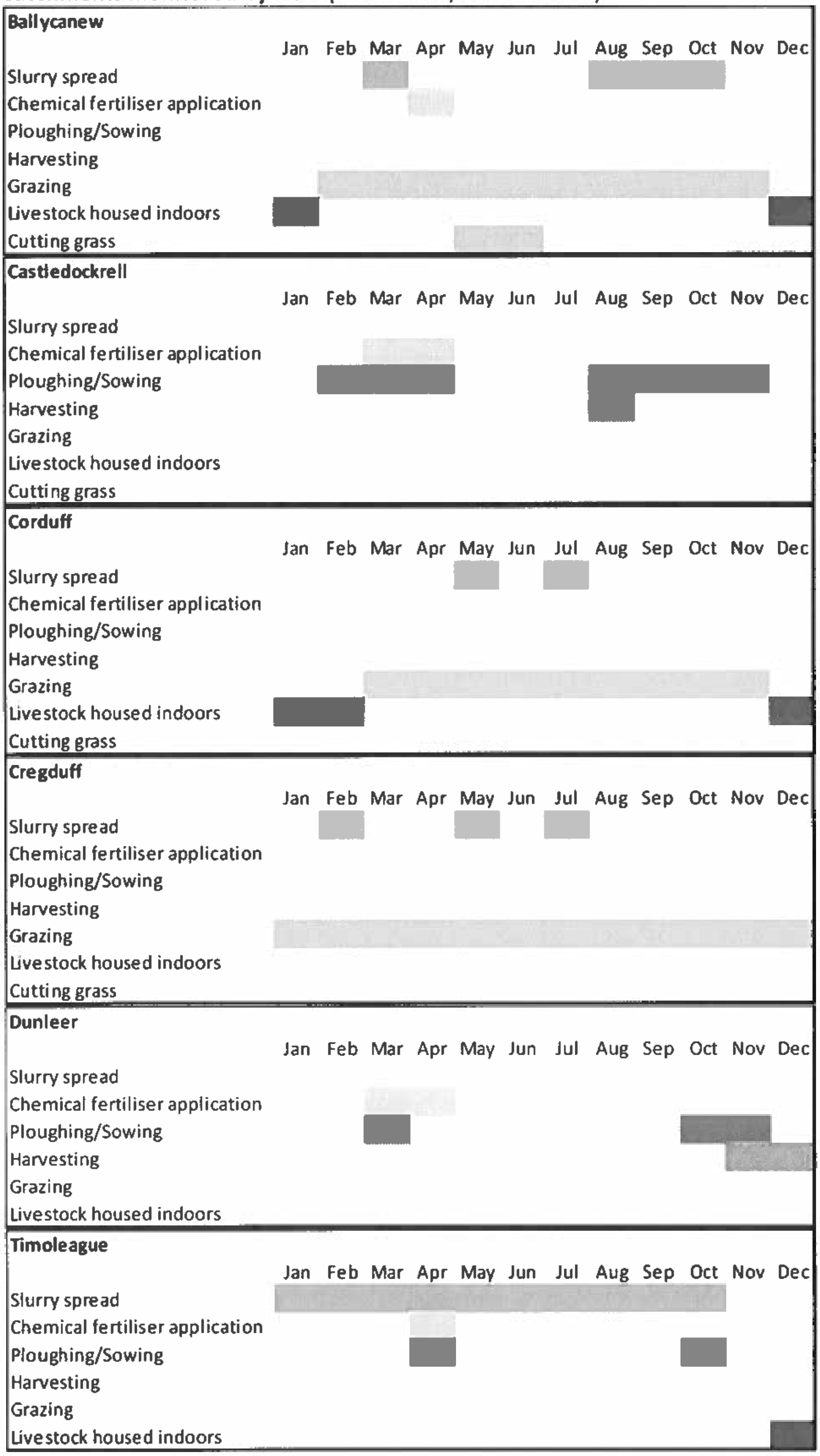
Prcp stands for Precipitation. The asterisks show significance of each variables: $p \leq 0.001$ "***"; $p \leq 0.01$ "**"; $p \leq 0.05$ "*"; $p \leq 0,1$ "*" (Ezzati *et al.*, under review)

The results revealed that the extent of the impact of climatic drivers depends on catchment characteristics. In earlier research by the ACP team the long-term shifts in weather patterns, as expressed by the North Atlantic Oscillation index, was found to influence both N and P concentration in the ACP catchments (Mellander *et al.*, 2018). Small point-source may significantly elevate P concentrations during an ecological sensitive period (Shore *et al.*, 2017). Hence, considering the accelerating occurrence of extreme weather events, more targeted approaches are required to deliver catchment-specific right measures, which in turn requires better understanding of underlying nutrient-loss processes (Melladnder *et al.*, 2024).

In addition, using the expert knowledge within the ACP, a farming calendar was developed for all the six catchments (Figure 6.4.10). This was to facilitate understanding the impact of farming practices along with climatic drivers on the dynamics of N and P in surface water.

According to the farming calendar and local catchment advisors, slurry spread during spring/summer time is more common in grasslands where as ploughing and fertiliser application take place during spring on arable land (Figure 6.4.11). For example, in *Castledockrell*, the significant increase of NO_3-N in April coincided with chemical fertiliser application and ploughing/sowing (Ezzati *et al.*, under review).

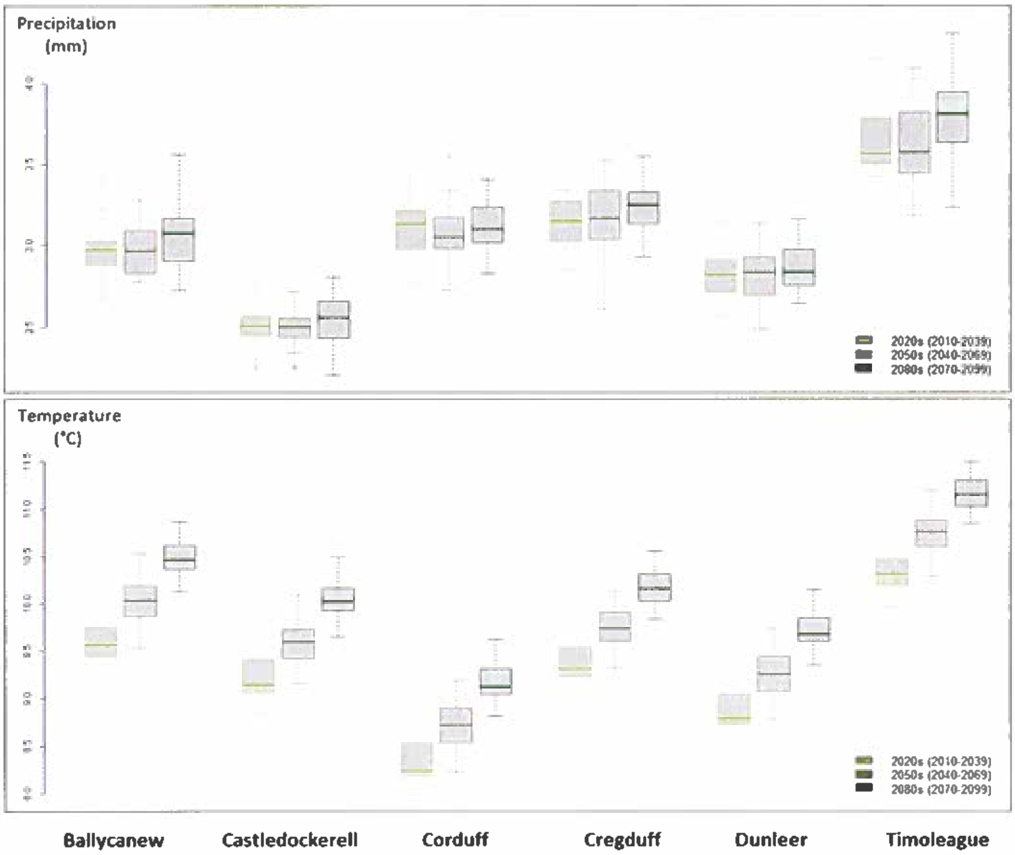
Figure 6.4.10. Summary of the typical farming calendar for each of the six catchments monitored by ACP. (Ezzati *et al.*, under review)



- **The triggering climatic factors and the possibility of flushing of the nutrients due to extreme hydrological events: Insight from projected climate change scenarios.** (Ezzati *et al.*, submitted)

In order to have an overview of the expected climate change and weather condition throughout the century, the ensemble of the climate models on the projected daily precipitation and air temperature data were extracted (Ezzati *et al.*, submitted). This ensemble is from COSMO-CLIM Version 5 (Nolan and Flanagan, 2020) downscaled to develop high resolution climate scenarios for Ireland, and included HadGEM2, EC-Earth, CNRM-CM5, MIROC5, MPI-ESM-LR. We applied the same emission scenarios and time periods as in Murphy *et al.* (2023) [developed within *WaterFuture Project*] who regionalised the models for two emissions pathways: an intermediate pathway in which the global emissions peak around 2040 then decline: RCP4.5, and a fossil fuel intensive future: RCP8.5. The time-slices are representing the 2020s (2010-2039), 2050s (2040-2069) and 2080s (2070-2099). This reports only contains RCP 4.5 results. Figure 6.4.11 shows the projected air temperature and precipitation across different time periods in moderate emission scenario of RCP 4.5.

Figure 6.4.11. Projected Precipitation (mm) and Temperature (°C) for three simulated reference period for Emission Scenario 4.5



Temperature is increasing stepwise (and significantly) in both scenarios RCP4.5 and RCP8.5 throughout the three time periods while stepwise increase in precipitation and temperature in Scenario 8.5. The range and percentage of increase in temperature in both scenarios 4.5 and 8.5 are the same for *Ballycanew* and *Castledockerell*. In Scenario 4.5., the percentage of increase in precipitation in *Ballycanew* is higher than *Castledockerell* (32% versus 23.9%), while in Scenario 8.5, it is higher in *Castledockerell* than in *Ballycanew* (with 43.86% versus 36% increase in precipitation, respectively).

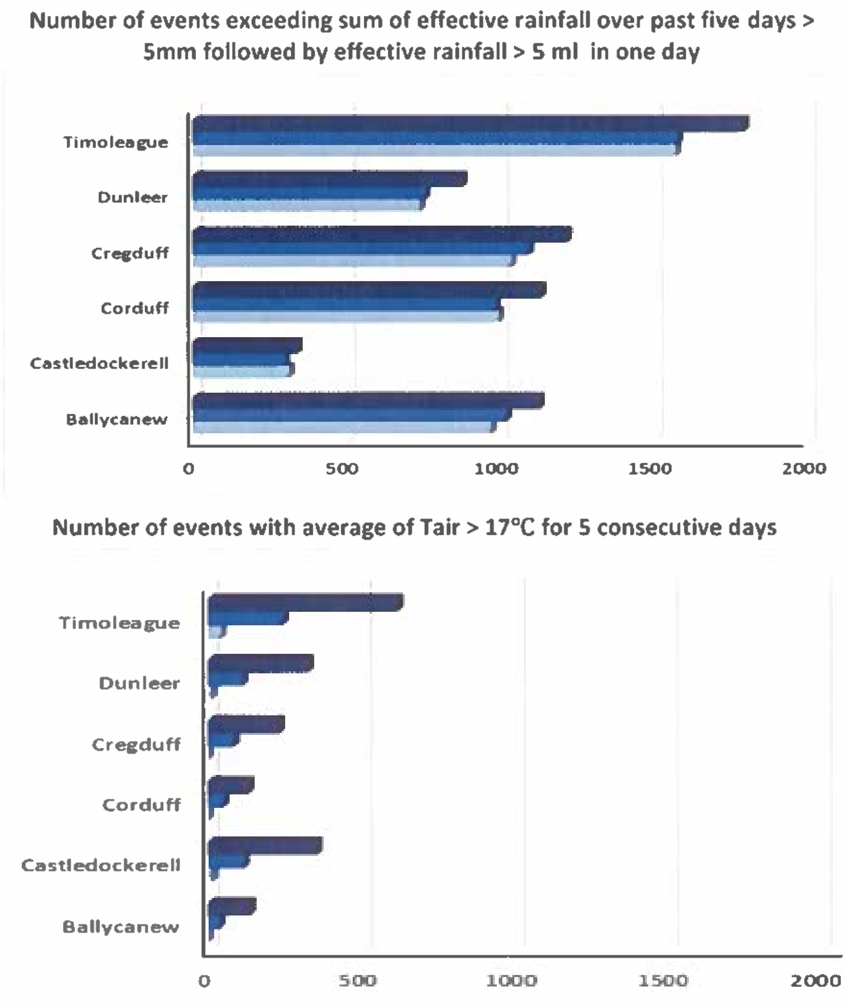
- **Possibility of the occurrence of extreme hydrological events triggering nutrient losses**

Empirical modelling using the ACP's 12 year water quality and met data (10-min basis) highlighted the weather conditions that have triggered flushes of N and P into the water. The analysis was spread across catchments and criteria were defined that would explain up to 50% of incident of losses assuming that antropogenic activities (farming practices) would remain as they are. It was established that sum of effective rainfall (total rainfall minus evapotranspiration) over past five days exceeding 5mm followed by effective rainfall over 5 ml in one day would cause flushes of P, whereas air temperature exceeding 17°C over 5 consecutive days would cause an increase in N losses.

The modelling revealed that considering projected climate change scenarios, all catchments would experience higher number of such incidents leading to these losses as we move toward end of the century. *Timoelague*, for example, would experience the highest number of P-related incidents followed by *Ballycanew*, *Cregduff*, and *Cordufff*. *Timoelague* is also expected to have highest number of N-loss incidents among other catchments (Figure 6.4.12).

These observations necessity development of catchment-specific climate smart mitigation measures as the sensitivity of each catchment to climate change is different.

Figure 6.4.12. The possibility of occurrence of triggering events of N and P losses using RCP4.5 emission scenarios during three time periods. (Ezzati et al., submitted)



Aquatic ecology and sediment impact

From 2009 to 2021 an annual ecology survey was carried out by the Aquatic Services Unit (ASU), University College Cork (UCC) twice (May and September) in the ACP catchments. In 2023, this has been completed by Woodrow Sustainable Solutions Ltd (trading under the name APEM). The survey assesses macroinvertebrates and diatoms at four to five sites along the river network in each catchment. Each sample at each site was scored under the following indices: Q value, Biological Monitoring Working Party (BMWP), Average Score Per Taxon (ASPT) and Small Streams Risk Score (SSRS). Diatom metrics and macroinvertebrate, which is main Biological Quality Element (BQE) determining the ecological status in rivers (required by the Water Framework Directive; WFD), have been expressed as Ecological Quality Ratios (EQR's). Inter-annual trends were assessed with the Mann-Kendal trend analysis.

To summarise the Q values of the five river catchments: *Corduff* catchment had the highest Q values across the study, these 'High' quality scores were restricted to the first four years of the study period. For both May and September, there was a gradual decline in quality over time, which could indicate an increase in local pressures from human activity. In *Dunleer* catchment the results indicate that water quality was impacted by human activity across the catchment. This impact was most evident during September sampling, with 'Poor' Q values inferring moderate pollution in the watercourse. In *Ballycanew* catchment there was a clear seasonal disparity in ecological water quality between May and September samples. In general, water quality was poorer during September sampling events. In *Castledockerell* catchment the ecological quality was generally 'Good' during May sampling events, and 'Moderate' during September sampling events across all sites. Three of the sites saw a decline in September Q values from 2015 onwards. Finally, *Timoleague* catchment had, with the exception of one site, good ecological quality during Spring-sampling. There was a marked decline in Q value in September samples for all sampling sites. But one site had lower Q values than the other sites across both sampling periods.

Excessive sediment can significantly impact the condition of freshwater habitats, resulting in a deterioration of water quality. Sediment can have a greater impact on freshwater insects (key indicators of water quality) than both N and P concentrations but is not used to validate the water quality status within the WFD.

Meso-scale catchments with low permeability exported larger suspended sediment yields than those with high permeability. Where arable land occurred on low permeability soils, the highest sediment export was recorded. High inter-annual variability resulted from rainfall fluctuations. The results indicate that catchment soil erosion risk can be classified according to soil drainage characteristics and land use type (Sherriff *et al.*, 2019). Suspended sediment export from five of the six ACP catchments was low compared to values for the UK and mainland Europe. This was attributed to greater density of landscape features such as hedgerows and drainage ditches which reduced field sizes, and act as natural mitigation measures (Sherriff *et al.*, 2015). Assessment of the provenance of suspended sediments highlighted that field topsoils, channel banks/sub-surface soils and roads were the dominant contributors to suspended sediments in the ACP catchments and contrasted between catchments *e.g.* grassland catchments dominated by low permeability soils with extensive sub-surface and surface drainage primarily exported sediment originating from channel banks due to delivery of high velocity flows from up-catchment drained hillslopes (Sherriff *et al.*, 2018).

Both soil drainage type and season have a significant influence in structuring macroinvertebrate communities. Poorly-drained catchments were most impacted, with communities dominated by pollution-tolerant taxa (O'hUallachain, 2019). Sediment was found to be a more pervasive stressor on freshwater ecosystems than N or P, with high sediment cover levels having the greatest negative impact on macroinvertebrate communities (Davis *et al.* 2018, 2019).

Table 6.4.4. Status of aquatic ecology and inter-annual trend (Mann-Kendal method) for the period 2010 – **2021 based on biannual sampling**. P = poor, M = moderate, G = Good, H = high, ↑ = improving water quality, ↓ = deteriorating water quality, → = stable (no change), -- = no trend for status of aquatic ecology.

2023 is averaged between monitored sites within each catchments, and during two sampling events

	Annual average ecological status 2010-2021		Average of sampling events 2023	
Name	**Macro-invertebrates**	**Diatoms**	**Macro-invertebrates**	**Diatoms**
Corduff	G ↓	G ↓	G	G
Dunleer	P ↓	M ↑	M-G	M-G
Ballycanew	M →	M --	P-M	P-M
Castledockerell	M ↓	M ↑	H-G	G
Timoleague	M →	M --	P	M
Cregduff	-	H ↑	M	H

The new report in December 2023, which was based on two sampling events in 2023, is consistent with results from APEM's ecological data review 2009-2021, however, there is also a suggestion of a further significant ecological quality decline in some of the catchments. According to the 2023 report, *Castledockerell* and the *Corduff* catchment had the best overall WFD ecological quality criteria, although both showed signs of ecological impact. *Cregduff*, despite having the highest diatom status, had the lowest scores in all macroinvertebrate metrics. *Ballycanew* catchment had the worst ecological quality overall, as both macroinvertebrate and diatom metrics combined were low overall.

Quantifying N and P losses from derogation and non-derogation farms

The current phase of the programme has been expanded to include monitoring of soil solution from a number of sites within farms in the *Timoleague* catchment. The selected catchment represents one of the most intensively managed agricultural areas in Ireland with predominantly well-drained soils vulnerable to nitrate leaching. Soil solution monitoring sites were selected based on multi-criteria approach, leading to sites similar in topographic and soil properties, but different in annual organic N loading and grassland management. The objective of this task is to monitor and report on soil solution N and P concentrations and loads from selected derogation and non-derogation farms and link them to existing surface water and groundwater monitoring in the catchment, which can then be modelled to quantify N and P loss to water by the programme catchment science modeller.

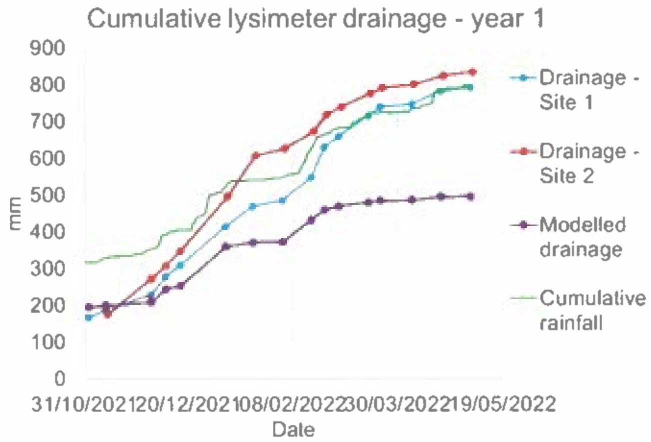
Two sites have been monitored for soil solution N and P since autumn 2021 – first site is located on low input grassland of non-derogation mixed farm, while the second site is located on intensively managed grazing paddock of the derogation farm. Two further soil solution monitoring sites have been established in 2022. Each monitoring site consists of 6 passive capillary lysimeters and 12 ceramic cup samplers, with a total of 24 lysimeters and 48 ceramic cup samplers installed during this phase of the ACP. All sites are located on the dominant soil type in the area (brown earths), but vary in terms of grassland management and annual N inputs representative of the area (Table 6.4.2). The entire monitoring equipment is designed to remain permanently underground, with only sampling access points located at the soil surface. This way, the monitoring equipment does not interfere with grazing or any other farming operation and thus provides a representative assessment of N and P leached from *in situ* farming and grazing scenarios.

Table 6.4.5. Overview of the soil solution monitoring sites in *Timoleague*.

Site no.	Site description	Farm type	Established (year)
1	Low input pasture	Non-derogation mixed farm (tillage and beef)	2021
2	Intensively managed grazing paddock	Dairy farm in derogation	2021
3	First cut silage field, in grazing rotation for the remainder of the year	Dairy farm in derogation	2022
4	First and second cut silage, then used in zero grazing system	Dairy farm in derogation	2022

When the results from the initial two sites for the first drainage season (2021/2022) were summarised it was found that the lysimeters were over estimating drainage. Figure 6.4.13 shows how drainage from the lysimeters was similar or in excess of cumulative rainfall. It was found that the lysimeters had dropped after installation and were receiving lateral water flow from the surrounding landscape. Remedial work was completed in 2023 to try and address this issue. In 2024, the team will test for potential mineralisation capability of N in the soils at each of the four instrumented sites. The objective will be to use the leaching data from the ceramic cups/lysimeters and soil N at depth to identify the mineralisation potential of soil organic N in the vandose zone.

Figure 6.4.13. Cumulative drainage from lysimeters compared to cumulative rainfall and modelled drainage over the same period.



Catchment Modelling

The ACP has established a comprehensive set of modelling objectives, which are designed to complement and expand upon the goals of the overall program. These objectives are to: (1) to select/develop/ adapt a catchment model(s) which best suit the programme; (2) to model N/P/ C losses from derogation and non-derogation farms; (3) to up-scale the findings of the ACP to larger catchments, river basin districts, and the national level; (4) to test environmental impacts of future agricultural, regulatory, and climate change scenarios; and (5) to carry out collaborative modelling initiatives with other modelling groups and dissemination activities.

The selected modelling approach will simulate N/P/C fluxes across the soil-water-atmosphere system and must be capable of representing the key physical characteristics and land-use practices in Ireland. There are a wide range of potential candidate models which are being explored which may be well suited to provide a baseline modelling approach (e.g. HYPE, SWAT, HSPF, and INCA). These models have existing functionality that suit many of the needs of the program, and the potential for further development and adaptation to extend their functionality to meet additional needs. Regardless of the baseline approach(s) selected, in order to upscale ACP results to larger spatial scales, models will need to be capable of functioning across a wide range of spatial scales, ranging from the scale of field (~2ha) to the farm scale, and up to the large catchments and national scale. This is likely to necessitate the adoption of a multi-model approach, utilizing different models across different spatial scales, to adequately simulate processes across scales without excessive predictive uncertainty. For example, to effectively simulate agricultural scenarios, we will need to be able to represent field-scale changes in land-cover / land-use, such as agricultural BMPs, which may need to be approached using varying methods depending upon the scale considered. In addition to working across spatial scales, we will also need representation of fluxes over long temporal scales, in order to simulate agro-environmental measures in conjunction with regulatory and longer-term climate projections. This is particularly important for the study sites of the ACP, where previous research has shown that the impact of weather systems may override mitigation measures, and that there may be a significant lag time (years to decades) between the implementation of measures and detectable changes in N and P fluxes.

During Phase 5 of the project, ACP aims to expand the application of empirical modelling studies in analysing high temporal resolution monitoring data and coupling it with projected climate change scenarios in order to facilitate better understanding of current and future challenges to water management. The information would be transferrable across Ireland, and the world, as ACP catchments are representative of different types of catchments at a national scale. This would not only contribute to Climate Action Plan of Ireland, but also to UN Sustainable Development Goals 2030 Agenda (SDG 6: Clean Water and Sanitation; SGD 13: Climate Action). Hence, the unique database and ongoing high resolution water quality monitoring conducted by ACP project puts Ireland in unique position within EU as a pioneer in researching long-term water quality-climate change linkages at catchment scale.

To help meet the wide-ranging modelling goals of the ACP project, we are actively working with and establishing new connections with national and international research groups, to benefit from their accumulated experience and expertise. In particular, by working with expert modelling groups from research partners, we can work with them to test additional models and research hypotheses beyond our core 'in house' modelling efforts. This will bring added-value to the extensive data collected by the program, by simultaneously evaluating models which may utilized to meet ACP goals and helping to validate existing models using the unique long-term high frequency datasets collected by the program.

Additionally, in 2023, DAFM requested Teagasc to model the impact Nitrogen management strategies within grass based dairy systems

This is published and available at;

https://www.teagasc.ie/media/website/publications/2023/The-Impact-of-Nitrogen-Management-Strategies-within-Grass-Based-Dairy-Systems.pdf

Greenhouse gas and carbon sequestration

The baseline data collection in the ACP has been extended to align with the Water Framework Directive (WFD) and include measurements of greenhouse gas (GHG), ammonia emissions, and soil carbon sequestration across the catchments.

Five eddy covariance flux towers have since 2020 been deployed in four of the catchments to provide *in situ*, high resolution (10 Hz) measurements of carbon dioxide and water vapour concentrations in air. The main objective is to monitor long-term CO_2 fluxes for arable and grassland ecosystems, and examine how soil drainage, management practices and land-use impact on the magnitude of GHG fluxes. Meteorological data is also collected at each site to help interpret and model GHG fluxes. The eddy covariance flux towers monitor net ecosystem CO_2 exchange (NEE), gross primary productivity (GPP) and ecosystem respiration (Re). The initial results show larger magnitude of NEE, GPP and Re in intensively grazed and zero-grazed grasslands that are subject to frequent grazing/defoliation followed by recovery of photosynthetic potential. The continuously grazed drystock grassland exhibited lower NEE and GPP rates but smaller seasonal fluctuations in daily fluxes which may reflect the reduction in nutrient availability to support higher GPP. However, the drystock grazed grassland had significantly higher soil water content which may stimulate higher soil CO_2 respiration resulting in lower NEE over time. Management practices involving defoliation and nutrient supply influenced affected season CO_2 exchange but longer-term flux monitoring is required to assess the net ecosystem carbon budgets of each grassland system.

Ambient atmospheric ammonia concentrations are being actively monitored at two flux tower sites from 2022.

Soil organic carbon has been quantified at two of the flux tower sites to $\geq$ 0.5 m depth so far with the remaining to be completed. A combined repeated soil inventory and carbon flux measurement approach will be used to assess the soil organic carbon stock changes over time. The different soil fractions and particle sizes will also be analysed to provide insights into the mechanisms of carbon stabilisation in agricultural soils.

Knowledge exchange and Stakeholder engagement

The understanding of processes influencing nutrient loss to water gained by the ACP has been used by other programmes in Teagasc in order to improve environmental outcomes in different settings. The

Agricultural Sustainability Support and Advisory Service (ASSAP) are working in EPA identified priority catchments or "Priority Areas for Action" (PAA). Both Teagasc and Dairy Industry Ireland ASSAP advisors receive training from the ACP and use this information to give site specific recommendations targeting the relevant issues for the site / field / farm or catchment.

PastureBase Ireland is an online tool to assist grassland farmers manage the grass production and utilisation. All farmers in derogation must budget their grass and PastureBase Ireland is used to do this. This programme continues to use tools that minimise surplus nitrogen: (i) a nitrogen use efficiency calculator gives farmers a farm nitrogen balance and benchmarks this with their peers and top performers, (ii) a nitrogen planner gives monthly nitrogen recommendations matching stocking rates and growing conditions, and (iii) a grass growth model (MoSt) predicts grass yield specific to each farm twice weekly for the following seven days. Weather data, Soil type and farm management information from PastureBase itself informs the model. This allows farmers to target nitrogen applications at the most efficient time. The initiative for these additions has come from ACP monitoring and reporting; it has contributed to a reduction in national artificial nitrogen use on grassland in 2023 of more than 30% in comparison to 2018.

Four agricultural advisors in the programme provide a service to all farmers with land in the six catchments, numbering just over 300. Most contact with clients is one-to-one, through on-farm visits, office consultations or phone calls and the advisors deal with all aspects of the farm business including farm husbandry & production, financial performance and schemes & regulatory compliance. Discussion groups attended by farmers from the catchments are also facilitated by the catchment's advisors. However, it is important to be aware that not all farmers are members of such groups. The good advisor/client relationship is reflected in the number of ACP farms that have facilitated research through siting of monitoring and experimental sites, and in many cases catchment farmers have suggested or influenced the research topics investigated by the ACP. The broad focus of the advisory service facilitates the collection of environmental, economic and production data from the farms, which is used by researchers in the programme.

The agricultural advisors also disseminate results of the programme to the wider farmer audience and other stakeholders. Other KT activities include presentations to visiting third level college courses, agricultural students, farmer discussion groups and courses, policy agencies and researchers. The mid-term review of the Nitrates Derogation in 2023 led to an increased focus on the ACP in general, and on the *Timoleague* catchment in particular. Table 6.4.6 overleaf sets out details of the ACP's Knowledge Transfer events in 2023.

Table 6.4.6. Knowledge Transfer events in 2023.

Event	Group	Catchment	Date
Co-op staff training	Carbery group	*Timoleague*	2nd February
MEP visit	FG Dairy Farmers	*Dunleer*	3rd February
International Student Visit	Penn State	*Ballycanew*	9th May
ACP open Day	Public	*Timoleague*	12th May
ICMSA, Senator Tim Lombard & Minister Hayden	Politicians & Farm Org.	*Timoleague*	6th July
Politician informing	Cork Lord Mayor & TD	*Timoleague*	17th August
Informing Teagasc Management	Teagasc Authority	*Timoleague*	6th September
Informing Policy	Policy-Science Working Group NWEU	*Timoleague*	3rd October
Politician Update	Tánaiste, Minister for Ag & Carbery co-op	*Timoleague*	14th October
TV programme filming	Ear to the Ground	*Timoleague*	26th October
Scientific Conference	Catchment Science 2023	*Wexford*	7, 8 & 9th Nov
Government Staff Training	DAFM Cross Compliance	*Timoleague*	8th December

In addition to peer reviewed publications by ACP researchers in scientific journals, the advisory staff have used popular press, radio interviews, Twitter, and You-tube videos to transfer knowledge form ACP research.

6.5. Agricultural Sustainability Support and Advisory Programme (ASSAP)

The ASSAP advisory service is an industry wide collaborative approach to improving water quality in Ireland.

Free and confidential farm visits are available to all farmers in Priority Areas of Action where water quality is at risk from agricultural activity. There are 50 advisors, 20 in Teagasc and 30 in Dairy Co-ops (June 2024). ASSAP work with the Local Authority Waters Programme (LAWPRO). LAWPRO conduct a scientific investigation and provide agricultural referrals to ASSAP advisors to focus farm visits.

In 2021 an external review[1] of the programme was published and provided some high level findings and recommendations including providing funding to support farmer's implementation of actions which led to the development of the 'Farming for Water' European Innovative Partnership (EIP).

6.6 Farming for Water European Innovation Partnership

In March 2024, the Department of Agriculture Food and Marine (DAFM) in collaboration with the Department of Housing, Local Government and Heritage (DHLGH) launched a €60 million European Innovation Partnership (EIP-AGRI) "Farming for Water" project aimed at implementing commitments at local, catchment and national level in partnership with the agri-food industry to improve water quality. The DAFM and European Commission will co-fund €50 million for farmer actions, with the objective of involving 15,000 farmers in priority areas nationally, and the DHLGH will provide funding of €10 million to cover the project's administrative costs.

The project measures will be designed and implemented in collaboration with farmers and will be targeted specifically to reduce losses of nutrients, sediment and pesticides from agricultural lands, i.e. 'breaking the pathway from point source'. The project will focus on areas needing the most attention to protect water quality.

The EIP is co-funded by the European Commission and the Irish Government as part of Ireland's Rural Development Programme and will be continued under the CAP Strategic Plan.

[1] ASSAP-Expert-Review-Final-Report---pdf--22-Nov-2021.pdf (teagasc.ie)

This project is a key component in Ireland's ongoing efforts to improve water quality and the sustainability of Ireland's agricultural practices at a national level. It is just one part of a greater collection of measures taking place at present to support those efforts. This includes a national multi-actor Water Quality Advisory Campaign, led by Teagasc as well as committing to increased compliance and enforcement obligations across government Departments and Local Authorities.

In developing the EIP, an operational group has been established by the Local Authority Waters Programme (LAWPRO), in partnership with Teagasc, Dairy Industry Ireland (DII) and Bord Bia, and with the support of other stakeholders, to work in partnership with farmers in the implementation of a number of targeted actions at farm level.

This EIP initiative involves a range of stakeholders (for example, farmers, advisors, researchers, non-governmental organisations) coming together in what are termed 'Operational Groups' to trial innovative solutions that the Group themselves have developed.

Access to the Farming for Water EIP will be prioritised using a tiered system and farmers will be approached to make applications. The following is a list of some of the measures that will be potentially available to address farmyard issues and land management issues in relation to improving water quality – the aim is to 'break the pathway':

- Hedgerow establishment
- Additional fencing for bovine exclusion from water bodies
- Alternative Water Supply – Pasture Pump/Solar Pump/Water Trough
- Riparian Buffer Zones
- Tree planting
- Small Scale Ponds
- Earthen bund
- Sediment Traps
- Watercourse crossing/bridges
- Gateway relocation
- Multi Species Swards
- Pesticide mitigation measures

7. Summary

The influence of derogation in Ireland has been assessed at small catchment scale by detailed water quality monitoring of surface and groundwater bodies in intensively managed agriculturally dominated catchments with different physical settings. The selected catchments represent Ireland's great variety of soil types, geology, and farming practices. The heterogeneous physical settings largely influence the nutrient transfer pathways and the associate transformation process along the pathways.

At the scale of the ACP catchments these settings can override the source pressure causing a poor link between nutrients leaving the root zone and nutrients monitored in the stream water. **The percentage of land in derogation within the ACP catchments was not reflected in the water quality in the streams. In the catchment with most land in derogation and with a gradual increase in annual organic N loading there was no increase in nitrate-N concentration in groundwater. In the catchment with no derogation and only minor increase in organic N loading there was an increase in the nitrate-N concentration in groundwater.**

A clear weather signal in both N and P concentration has been found in streams in the Irish ACP catchments and in other catchments in NW Europe. Using a minimum of four years of data, as required for inter-annual trend analysis, monthly and annual trends in nutrient dynamics have been investigated. At the sub-catchment scale (*ca.* 1 km2), there was no clear relationship found between source N loadings and stream water nitrate-N concentrations as it is a complex system influenced by various factors simultaneously. However, **there was a statistically significant relationship between the climate and the hydrological characteristics of catchments and the stream water nitrate-N concentrations. Air temperature (and prolonged warm period) followed by heavy rainfall would trigger N losses whereas prolonged wet periods followed by rainfall exceeding 5 mm over one day would cause an increase in P losses**. The relative importance of the drivers and controls of N losses were mediated by site specific characteristics. Thus, it is important not to only continue high resolution monitoring of surface water quality, but also consider the catchments characteristics while evaluating their sensitivity against extreme weather events (climate changes). These results also highlight the importance of best timing for nutrient application on the farms.

The unique database of the ACP and the fact that selected catchments are representative of the majority of different catchment-physical settings has put Ireland in a unique position within the EU as a pioneer to meet it's UN Sustainable Development Goals regarding climate change. It is, hence, vital to focus on the development of climate smart mitigation/adaptation measures that are catchment-specific.

Sediment can have a greater impact on key indicators of water quality than N and P concentrations as well. The heterogeneous physical settings and land use also largely influence the suspended sediment transfer.

The fifth phase of the ACP includes detailed farm-scale experiments and monitoring of N and P concentrations in soil solutions, surface water, and groundwater on derogation and non-derogation farms, in view of the changing weather patterns and more frequent extreme weather events.

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Appendix 1

Ireland Nitrates Derogation 2022*

Figure 1.1. Derogation as percentage of whole country

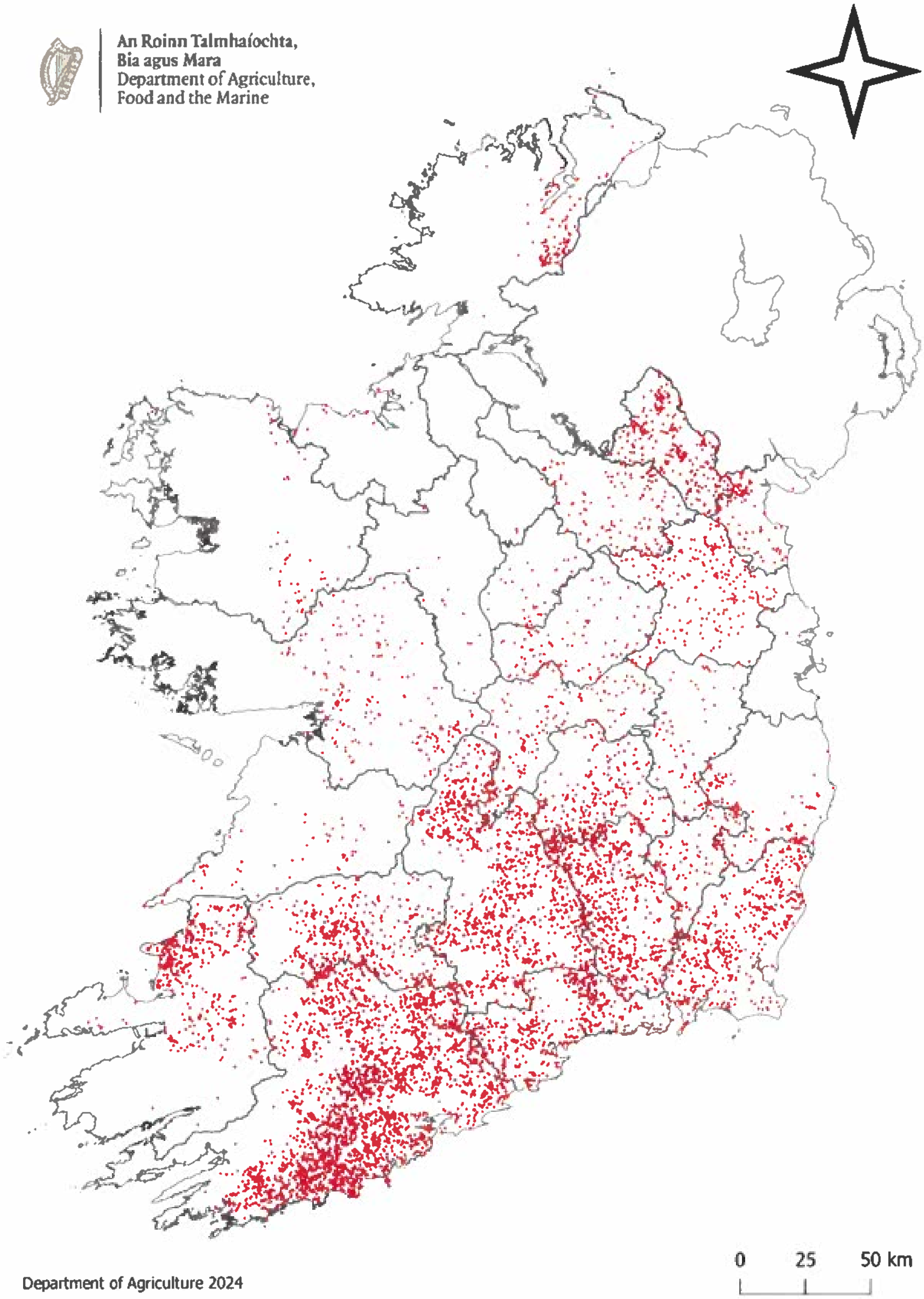
2022	Derogation farms as % of whole country
Number of holdings with grazing livestock	5.14%
Number of grazing livestock units	23.59%
Total net area	10.54%

**Note: Data for 2023 will be provided based on final calculations when all administrative checks relating to 2023 have concluded.*

Appendix 2

Figure 2.1. Geographical spread of Ireland's Nitrates Derogation applicants 2023.

An Roinn Talmhaíochta,
Bia agus Mara
Department of Agriculture,
Food and the Marine



Department of Agriculture 2024

Appendix 3 – *Provided as separate documents*

Documentation relating to Nitrates Derogation in 2023

Terms and Conditions 2023

Fertiliser Accounts 2023

Note 1 – farmers applying for a Nitrates Derogation were obliged to make on-line application in 2023

Note 2 - 2023 Nitrates Derogation Fertiliser Plan: New or Amended Plan

Where a new or amended Fertiliser Plan was submitted in 2023, only a plan produced by either the Teagasc online Nutrient Management Plan programme (eNMP) or the Farmeye Nutrient Management Plan programme was acceptable.

Appendix 4 – *Provided as separate documents*

Maps

Map 1: *Percentage of holdings with grazing livestock encompassed by Derogation in 2022 at county level*

Map 2: *Percentage of grazing livestock units encompassed by Derogation in 2022 at county level*

Map 3: *Percentage of net area encompassed by Derogation in 2022 at county level*

Appendix 5 – *To be provided as a separate document*

EPA Report - ***Water quality monitoring report on nitrogen and phosphorus concentrations in Irish waters 2023***.

Appendix 6

Surveys on local land use

The results of the surveys on local land use, crop rotations and agricultural practices referred to in Article 10(5) of Commission Implementing Decision 2022/696.

The below information is taken from Ireland's CSO Census of Agriculture which takes place every 10 years[2]. The most recent census was undertaken in 2020 and the census prior to that was undertaken in 2010.

The information below is for the year 2020 and any comparisons are made with the year 2010.

In terms of farms by type specialist beef production was the most common farm type accounting for over half of all farms in 2010 (Figure 6.1) with figures similar to the 2020 census (Figure 6.2).

Figure 6.1. Farms by type, 2010

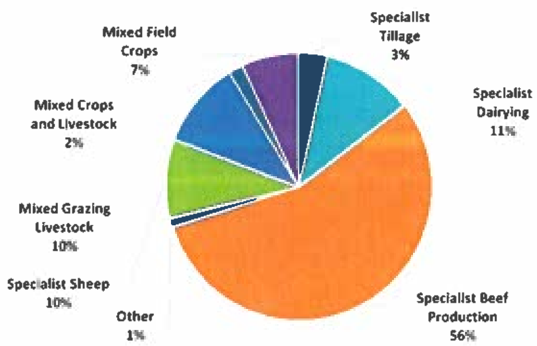
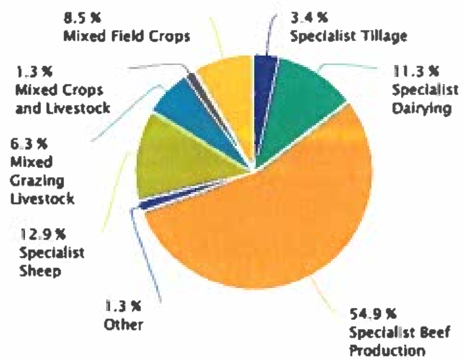
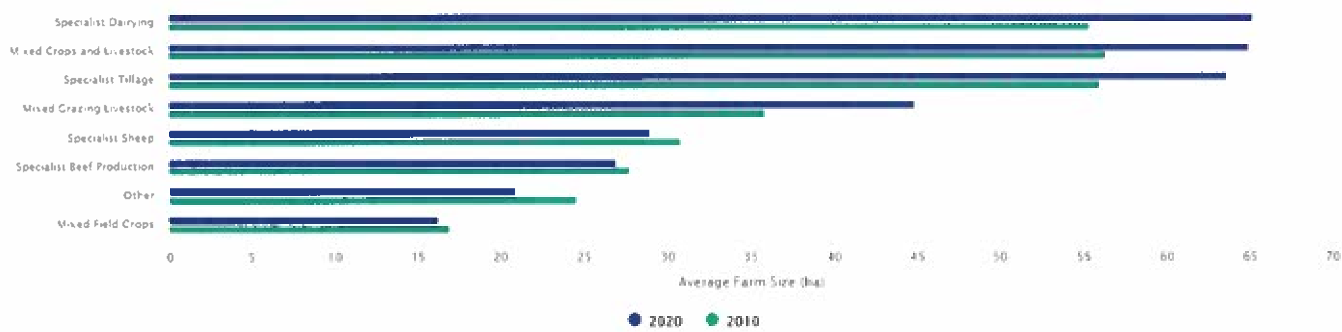


Figure 6.2. Farms by type, 2020



In terms of average agricultural area utilised by farm type, specialist dairy farms were found to be the largest farms in 2020 (Figure 6.3)

Figure 6.3. Average agricultural area utilised by farm type (2010-2020)



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[2] Introduction and Overview of Results Census of Agriculture 2020 - Preliminary Results - Central Statistics Office

Ireland's total agricultural area for 2020 was 4,509,256 ha with 3,699,919 ha of grassland (silage, hay and pasture) and 451,537 ha rough grazing, 265,592 ha of cereals. Other crops, fruit and horticulture accounted for 92,208 ha.

Table 6.1 below shows the breakdown of the cropping area per county for 2020 which can also be seen in the maps below (Figures 6.4, 6.5 and 6.6).

Table 6.1. Total grassland (silage, hay and pasture), cereals (wheat, barley and oats) and other crops (fruit and horticulture) for the year 2020 for each county. The difference in trend since 2010 is shown in brackets – in red where area has decreased and in green where area has increased.

County	Total Grassland (hectares) (difference compared with 2010)	Total Cereals (wheat, barley, oats) (hectares)	Total other crops, fruit and horticulture (hectares)
Cavan	124393.5 (-5,994)	..	..
Donegal	168075.6 (-3,954)	4,372 (-1,752)	2,559 (533)
Leitrim	73797.3 (-8, 475)	..	..
Monaghan	98520.4 (-3,000)	295 (-38)	578 (208)
Sligo	98906.1 (-3,474)	95 (53)	464 (364)
Galway	279759.5 (-12,689)	2,912 (-578)	3,364 (2,009)
Mayo	227171.3 (-8,334)	306 (-54)	1,282 (1,050)
Roscommon	154612.7 (-6,997)	569 (-87)	1,386 (1,058)
Clare	172807.8 (-13,517)	164 (100)	754 (621)
Limerick	194005 (-2,298)	844 (-79)	683 (-452)
Tipperary	278510 (2,706)	19,632 (-1,427)	5,028 (847)
Carlow	49233.7 (-654)	14,889 (279)	4,134 (585)
Kilkenny	142538.6 (2,111)	13,223 (-1,839)	4,550 (503)
Waterford	106523.8 (-287)	6,463 (-995)	2,798 (-247)
Wexford	123446.5 (-2,707)	42,660 (936)	12,008 (1,961)
Cork	442118.7 (2,999)	35,423 (-5,096)	11,248 (-3,375)
Kerry	207247.9 (-6,717)	1,998 (302)	766 (-188)
Dublin	15437.1 (-2,642)	11,021 (-86)	4,856 (-1,738)
Kildare	77338.3 (-2,313)	27,667 (818)	5,869 (1,907)
Louth	39267.3 (1,125)	15,766 (-574)	4,396 (-247)
Meath	153058.1 (3,129)	28,255 (703)	11,646 (2,175)
Wicklow	80197.6 (-1,451)	10,727 (1,529)	3,236 (498)
Laois	100343.3 (-575)	14,680 (-69)	3,475 (614)
Longford	66357.9 (-2,985)	294 (91)	805 (665)
Offaly	108288.5 (-1,933)	8,692 (-356)	2,765 (860)
Westmeath	117962.9 (1,110)	4,539 (-141)	2,636 (1361)
Total	**3699919.4 (-77,815)**	**265,592 (-8,306)**	**92,208 (12,179)**

Information taken from Land Utilisation section of the Census of Agriculture 2020 – Preliminary results from the Central Statistics Office[3]. Data for cereals and other crops in Cavan and Leitrim has been suppressed for confidentiality purposes.

[3] Land Utilisation Census of Agriculture 2020 - Preliminary Results - Central Statistics Office

Figure 6.4. Hectares of Grassland per county in 2020

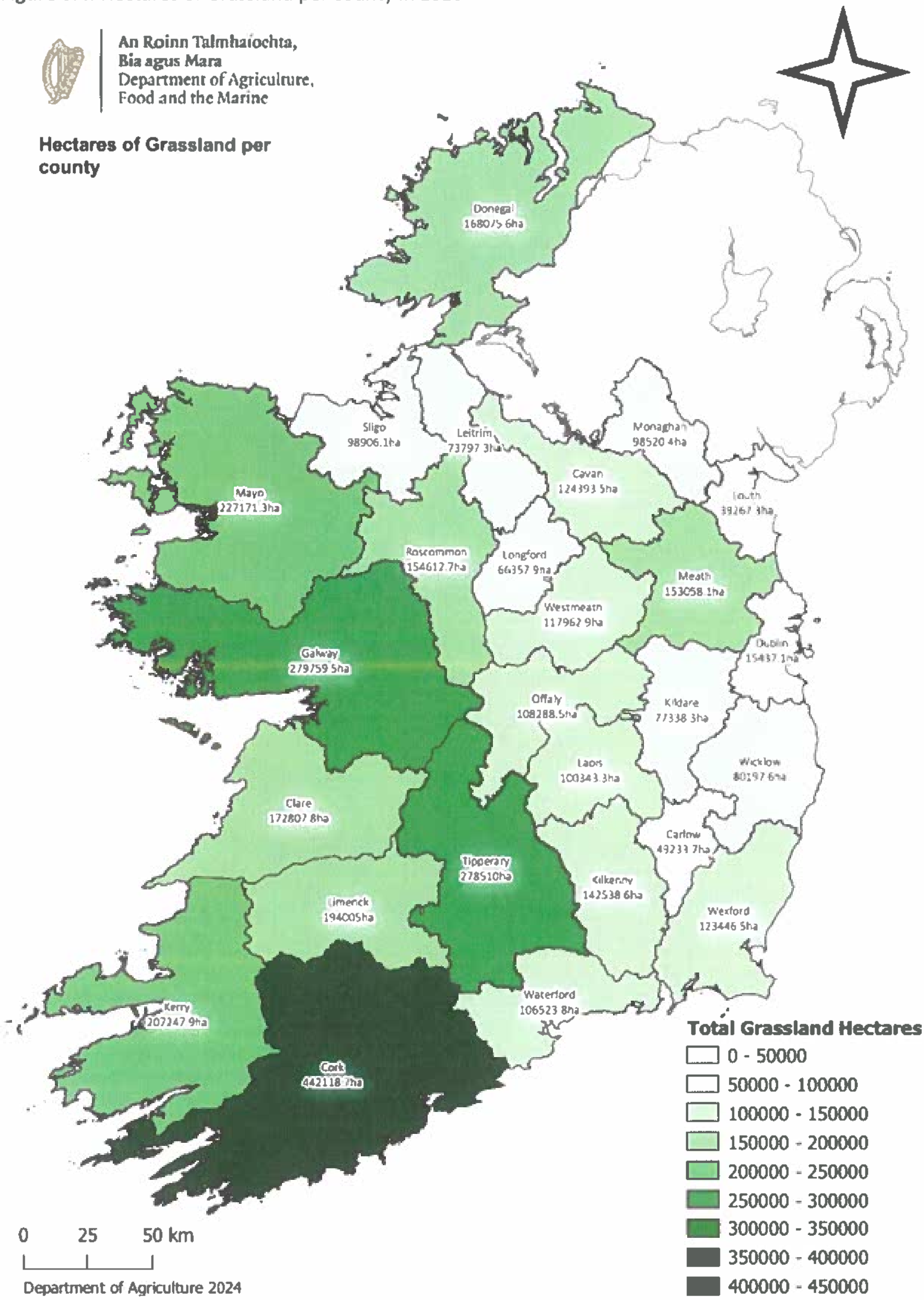


Figure 6.5. Hectares of Cereals (Wheat, Barley, Oats) per county in 2020

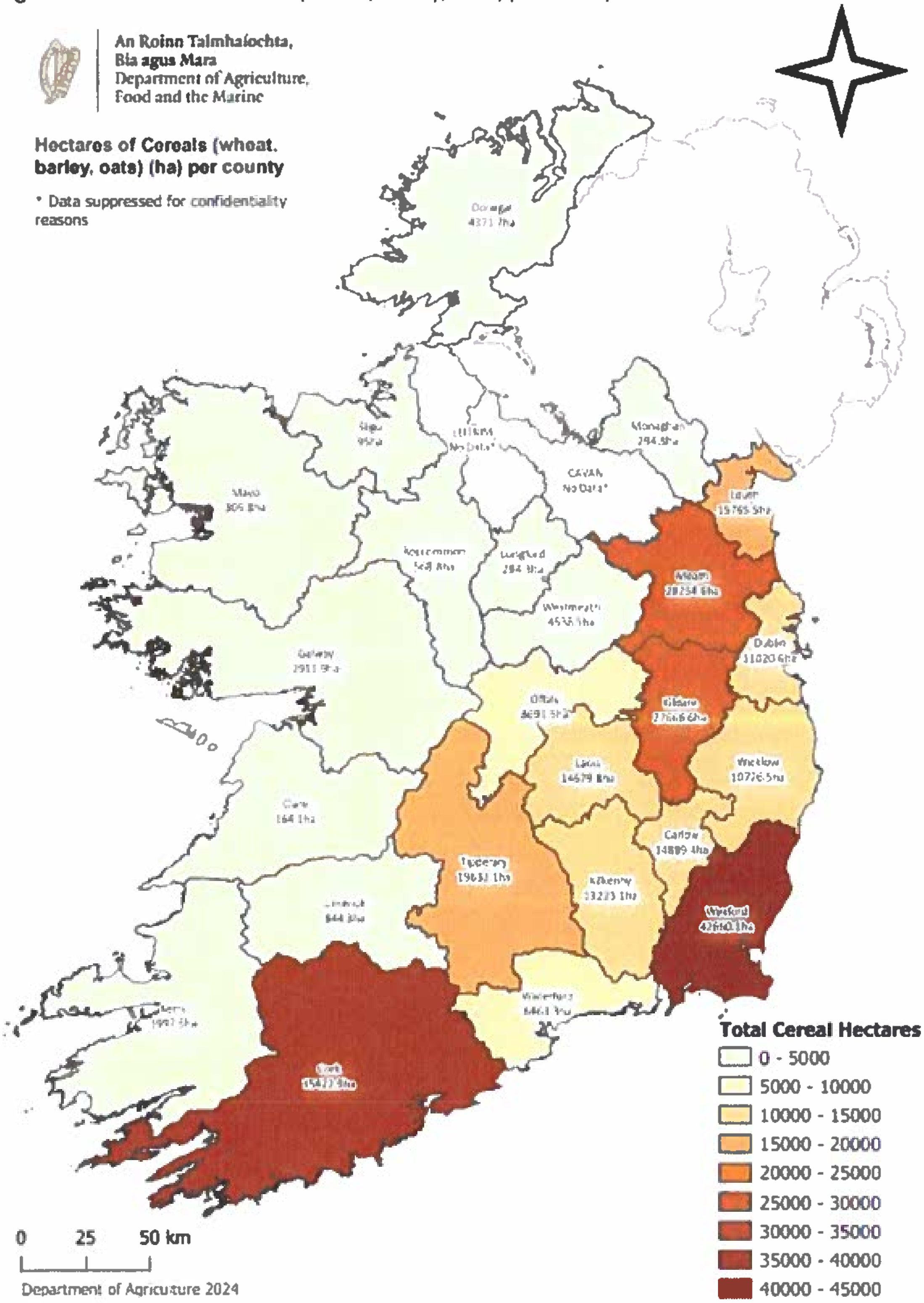
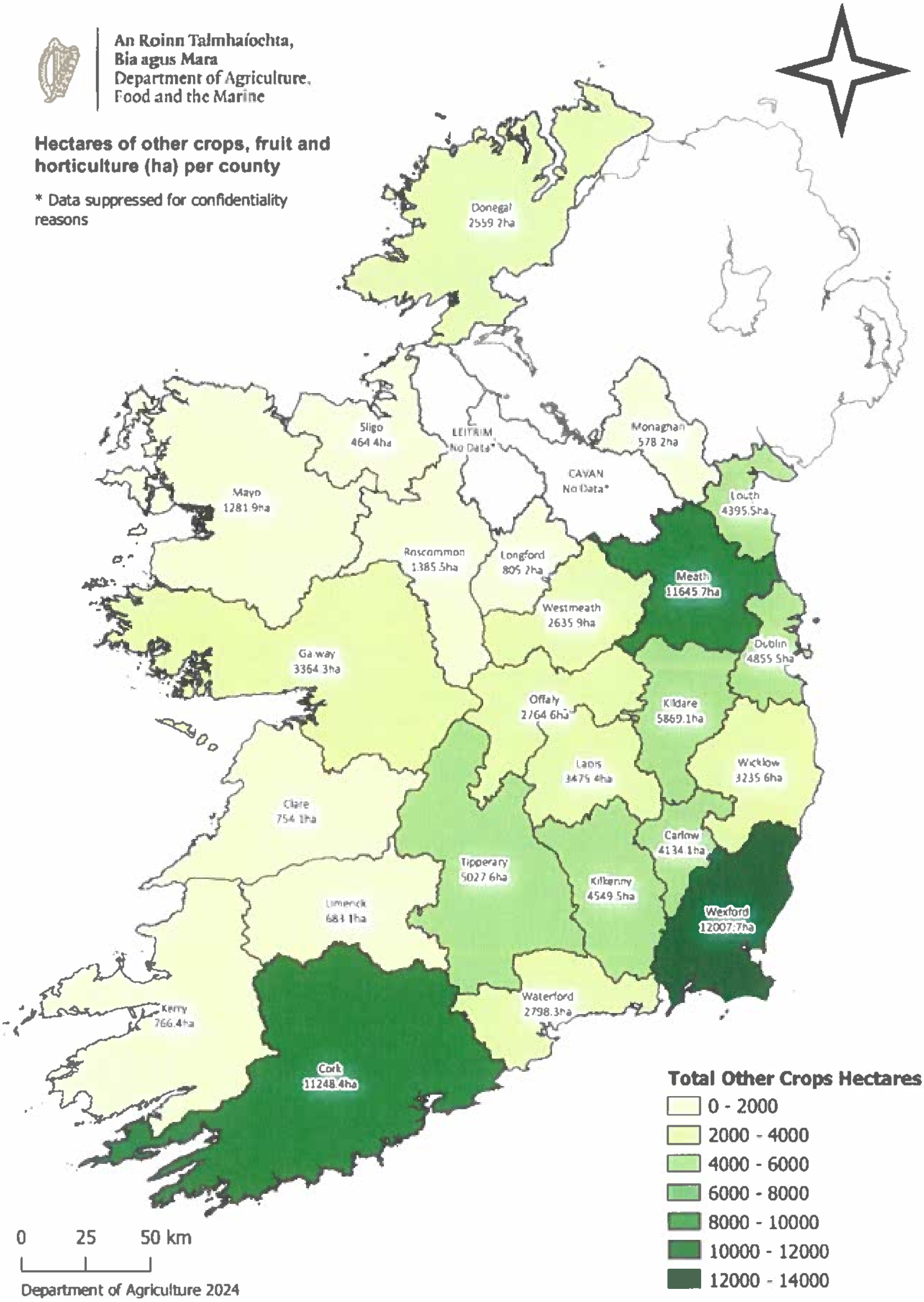
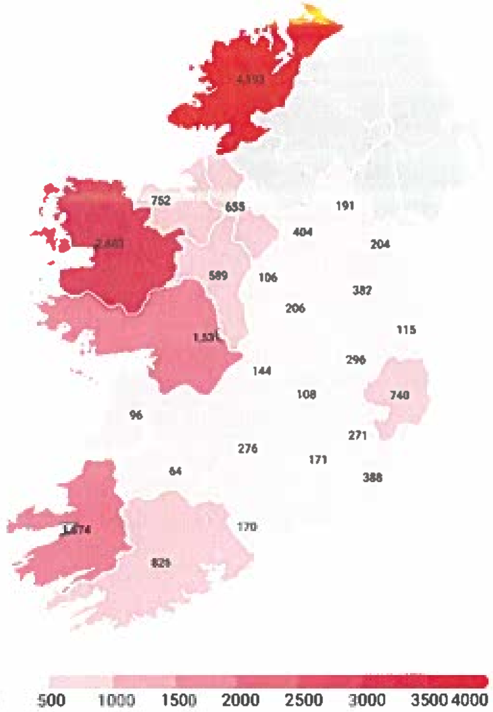
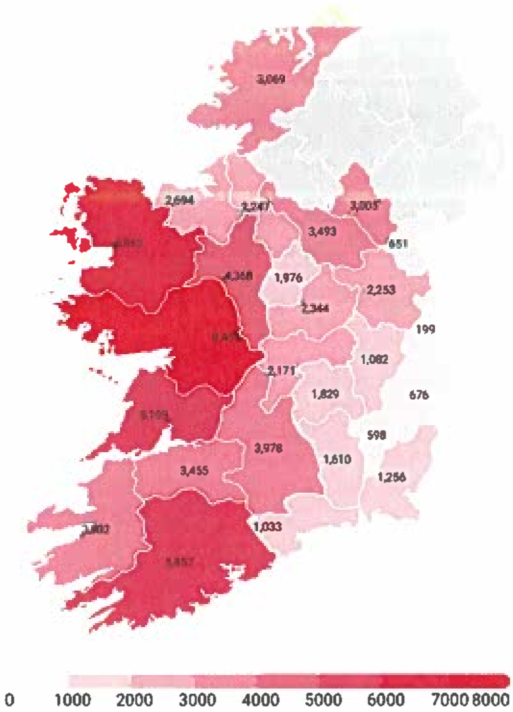


Figure 6.6. Hectares of other crops, fruit and horticulture per county in 2020



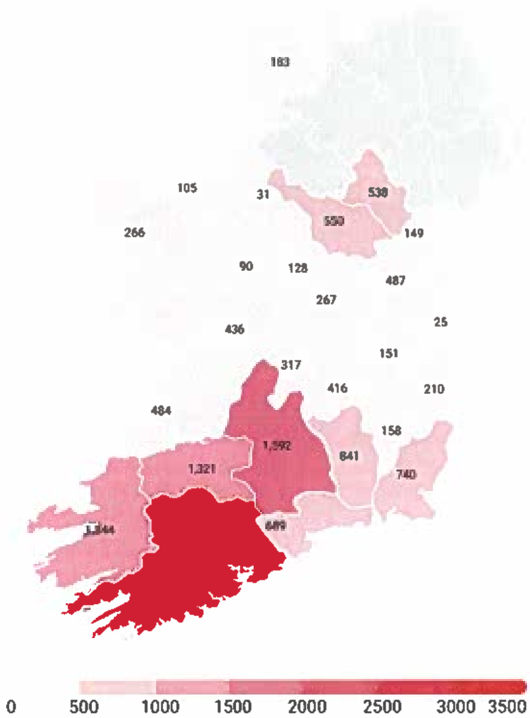


Distribution of Sheep farms IE (KPMG, 2023)



[4]

Distribution of Beef farms IE (KPMG, 2023)



Distribution of Dairy farms IE (KPMG, 2023)

[4] KPMG Agribusiness Report 2023

Appendix 7

Report from the interim review of water quality in 2023 – provided as a separate document.

Annex 1 of this report includes the requirement under Article 12 of Commission Implementing Decision 2022/696.

Appendix 8

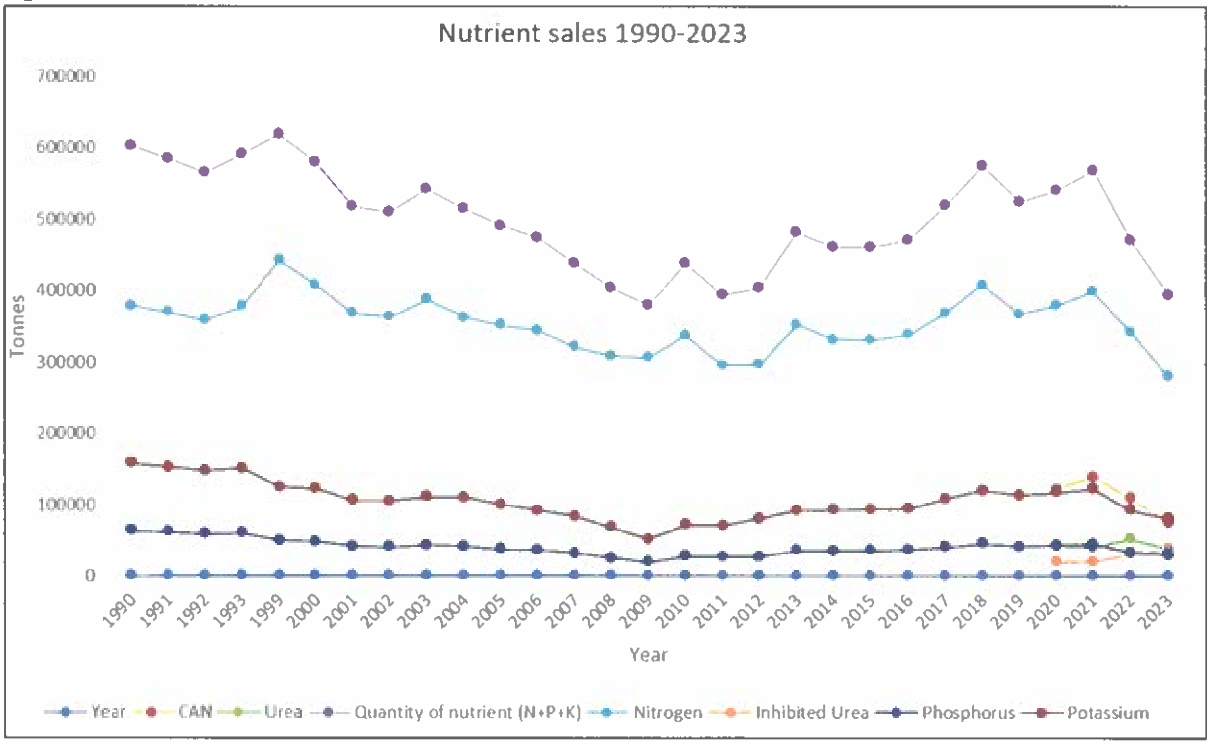
Trends in Chemical Fertiliser use in Ireland

Table 8.1 Total chemical fertiliser sales in Ireland 2021 – 2023

	2021	2022	2023
	Tonnes		
Total quantity of nutrient (N+P+K)	**568,154**	**471,047**	**393,287**
Nitrogen	399,164	343,193	280,569
Phosphorus	46,068	34,240	30,762
Potassium	122,922	93,614	81,956

Source: DAFM

Figure 8.1 Trend in total chemical fertiliser sales in Ireland 1990-2023



Source: DAFM

Ends.