EXECUTIVE SUMMARY

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This report describes and explains the relevance of the outcomes from Phase 2 of the Agricultural Catchments Programme (2012-2015) and follows on from the Phase 1 report (2008-2011).

The Agricultural Catchments Programme (ACP) is funded by the Department of Agriculture, Food and the Marine and is operated by Teagasc. Its core objective is to measure the effectiveness of the Good Agricultural Practice (GAP) measures implemented under the Nitrates Directive, i.e. the Nitrates Regulations, at catchment scale while also evaluating the efficacy of the nitrates derogation.

The scientific findings from the ACP help fulfil Ireland's monitoring and reporting requirements under the EU Nitrates Directive and the EU Water Framework Directive. Furthermore, the findings support key agri-environmental policies and strategies, including:

- The review of Ireland's Nitrates Regulations, including the nitrates derogation in 2017.
- The 2nd cycle of River Basin District Planning under the Water Framework Directive.
- Food Wise 2025 and scientific verification that Irish farmers are producing milk, meat and crops in an environmentally and economically sustainable manner.
- Origin Green and water quality in the context of marketing the sustainability of Irish food production on world markets.

The overarching conclusion of the ACP's work to date is that the implementation of the Nitrates Regulations by Irish farmers has improved water protection against pollution caused by nitrogen (N) and phosphorus (P) from agricultural sources. Further improving nutrient management on Irish farms by supporting farmers' nutrient management decisions, is the single change that can do most to help farmers protect and improve water quality. Better nutrient management can also deliver improved economic returns to the farmer by increasing the efficiency with which farmers use nutrients, i.e. producing more output for the same, or less, nutrient input. Win-win mitigation measures, such as this, that reduce risk to the environment while also increasing economic returns are the most likely to be voluntarily taken up by farmers.

In fact, when farmers adopt innovations which increase nutrient use efficiency, the environment benefits because more product, e.g. meat, milk, grain, is exported from the farm for a given level of inputs. There are many existing practices and technologies that can be adopted by farmers, each of which can make a contribution to improved production efficiency and reduce pressure on the environment. In addition, new techniques are constantly being developed to further improve production efficiency. Some examples of relatively recent practice innovations at varying stages of adoption are:

- The Economic Breeding Index (EBI) is a technology that most Irish dairy farmers adopted quickly in recent years and which has delivered substantial efficiency increases through accelerated gains in the genetic merit of Irish dairy herds.
- The NMP Online package which has been developed to produce more easily understood nutrient management plans for farmers including maps of their farms to clearly show where to apply nutrients.
- Improved grassland management techniques based on grass measurement and budgeting supported by software packages such as PastureBase which facilitate higher grass production and utilisation thus improving nutrient use efficiency.
- The €uro-Star system for beef cattle that guides farmers in selecting the most efficient and profitable animals to breed from.
- The Pasture Profit Index which can guide farmers in selecting grass varieties that best suit their needs.
- Better animal health management, as promoted by Animal Health Ireland, which improves animal performance.

When all these efficiency gains are accumulated they are likely to make a substantial and lasting difference to both economic and environmental performance.

The ACP approach, which uses high-resolution economic and environmental data gathered over successive years, is well suited to measuring changes in both these areas. These research outputs can be used to support Ireland's green credentials in the context of policy frameworks such as Food Wise 2025.

The strengths of the ACP approach

In the eight years since it started, the programme has continuously developed and established itself as a unique asset in meeting Irish farming's sustainable intensification challenge. Phase 1 (2008-2011) was concerned with project design, development and scientific assertion from the first years of data collection. Phase 2 (2012-2015) was mainly concerned with validation of assertions and policy impact. Phase 3 (2016-2019) will continue the approach established in the first two phases while developing the modelling area and expanding the dissemination effort.

The approach taken in the establishment and operation of the ACP has three key strengths which have served the programme well through Phase 1 and Phase 2.

First Key Strength

A single, common experimental design is used in all six agricultural catchments.

The bio-physical element of the design is based on the concept of a continuum from the source of farm nutrient to where that nutrient, if lost, would potentially cause an ecological impact. For N or P to impact on stream ecology (or downstream water bodies) it must pass through each stage of this continuum. Each stage is monitored and analysed to build up a better understanding of how the whole system works and to try to determine what conditions lead to increased risk of these nutrients impacting on water quality. This work entails high resolution monitoring, in both time and space, of the main physical parameters such as the N and P concentrations in the surface and groundwater, stream flow, weather data, soil nutrients levels and ecological status.

Second Key Strength

Integration of a strong socio-economic element with the biophysical component in the experimental design.

This integration enables the Programme to go beyond sophisticated monitoring and allows for the development of a deeper understanding of catchment processes related to changes in the agri-environment due to policy drivers. It also allows for key pressure and state expectations to be explained beyond just 'positive, negative or no change' over time. These are important considerations for Ireland's agri-environmental reviews and the support of the bio-economy and water resources.

Third Key Strength

Partnership with over 320 farmers across the six selected agricultural study catchments.

The active participation by these farmers and the goodwill that they have shown the ACP team has been essential in ensuring the success of the programme, in particular the socio-economic research. A high level of engagement with the farmers is achieved mainly via the four ACP advisers who provide an advisory service and collect farm data on nutrient management and economic performance.

Phase 2 Key Findings and Implications

By the end of Phase 2 (December 2015) the ACP had published over 50 peer-reviewed papers in international journals and well over 200 communication outputs. Phase 2 findings make up the main part of this report, showing key messages and a short synopsis of each in-depth study with a reference for further information. Insofar as the ACP approach and key strengths have found evidence for improved water protection, the programme has also identified remaining challenges and also provided considerations for potential solutions. The main body of the report is, therefore, separated into these three areas: Effects of the Measures; Understanding the Challenges; and Potential Future Solutions. Some of the most important findings with their policy relevance are summarised:

1. Declining Soil Phosphorus Trends

The proportion of fields in phosphorus (P) index 4 (in excess of crop requirement and noted in the Nitrates Regulations as having an increased risk of loss to water) has declined in four out of the five catchments reported on. However, the decline in soil P has additionally occurred across less fertile fields with the number of fields at phosphorus index 1 and 2 (very low and low agronomic status and with low risk of phosphorus loss to water in the Regulations) increasing indicating an overall decline in soil P levels rather than just a correction of high P levels. This reflects national trends in soil phosphorus decline which have led to approximately 66% of soil samples being at Index 1 or 2.

Positive nutrient management results have emerged from the intensive dairying Timoleague catchment (in West Cork). Changes adopted by farmers in how they manage their nutrients have led to a convergence towards index 3 - the optimum index for production with a reduced risk to water quality. There was a significant reduction in numbers of P index 4 fields and increasing soil P levels in index 2 and 3 fields. Analysis of the water data showed that there were subtle improvements in the quality of water in surface and shallow subsurface (mostly quickflow) flow pathways. It is likely that these improvements have not occurred in deeper groundwater and in the stream because of natural lags in the system. This favourable outcome in surface and shallow subsurface flow pathways water has not occurred yet in the other catchments.

Policy Relevance

More widespread and effective use of nutrient management plans by farmers is likely to improve both environmental and economic performance on farms. This is likely to be achieved only with appropriate advisory support for farmers in the interpretation and implementation of the plans.

2. Low use of Nutrient Management Plans

Further to the above finding, in a survey of ACP and non-ACP farmers who had a Nutrient Management Plan (NMP), it was found that over half of them answered that they did not have one. A farmer focus group was set up to get their views on the use of soil analysis results, recommendations and nutrient management. The farmers said that they found their current plans, which use tables of figures, difficult to use and favoured a simpler, flexible NMP approach combining a durable map with a table. For example, this would allow the farmer to keep the plan in the tractor cab and increase the chances of it being implemented.

Policy Relevance

The new Online NMP package was developed by Teagasc to address the need for farmer-friendly plans that was identified by the ACP work. The package enables farm advisers and consultants to deliver easy-to-use plans to farmers and is an important step in improving the effectiveness and

impact of nutrient management on Irish farms.
However, it has been found through ACP surveys that the plans on their own will not meet the farmer's needs and to increase their effectiveness, advisory support is required to help with interpretation. To be most effective, this support should extend to decisions on manure and fertiliser spreading regarding timing, soil type, application method and location.

3. Improved nitrogen and phosphorus use efficiency

Analysis of National Farm Survey data from 150 nationally representative dairy farms over seven years since the introduction of the Nitrates Regulations (2006 to 2012) found that N and P surpluses have declined without reducing output. Between 2006 and 2012 N surpluses declined by approximately 25 kg/ha and P surpluses by approximately 6 kg/ha.

Policy Relevance

These research findings provide strong evidence of improving efficiency of nutrient use, as a greater proportion of nutrient inputs are exported from the farm in product and less nutrient is available for loss to the environment. This evidence supports the sector in achieving its twin goals of increased economic competitiveness and environmental protection, as set out in Food Wise 2025.

4. Soil type and geology override soil P level as a predictor of P loss risk

The type of soil and subsoil being farmed has a greater influence on the risk of phosphorus loss to water than soil P levels or the P applied by farmers. The more poorly drained the soil the greater the risk of loss to water through fast surface runoff (such as overland flow).

Policy Relevance

A 'one size fits all' approach to how land and nutrient inputs are managed, that does not take account of the soil type and underlying geology, may not adequately address either phosphorus loss risk mitigation or agronomic needs. Thus, for example, in some poorly drained fields, soil P levels that are low by agronomic standards may pose a risk to water through fast surface runoff while on some well drained fields agronomically high soil P levels may pose little risk to water. This may have further knock-on effects to implications in point 1, above.

5. P loss to groundwater through the soil can be important in some settings

On some free-draining soils over half of phosphorus loss can be leached down through the soil to groundwater, although overall losses are generally low in these settings. These types of losses are governed mainly by soil P chemistry. P is fixed by iron and aluminium in the soil, but iron-rich soils may produce higher water soluble P concentrations leading to higher groundwater P which can add to river baseflow concentrations.

Policy Relevance

Where groundwater contributes significantly to streams and rivers the likelihood of P entering these surface waters via the soil and groundwater should be considered in any risk assessment. This builds on the ACP phase 1 findings of understanding the specific P vulnerability of groundwater in karst areas.

6. Point sources have a disproportionately large summer influence

In some catchments phosphorus concentrations in stream water increase as baseflow reduces during summer. This indicates a predominantly point source influence, since during the summer, low rainfall and dry soil conditions rarely, if ever, lead to circumstances that cause diffuse nutrient losses from farmland. This is especially evident in catchments with lower summer stream water levels due to low groundwater contributions (and especially where groundwater P contributions are low).

Policy Relevance

Point sources may have a disproportionately large impact on year-round stream ecology. Consequently, focussing on the reduction in the phosphorus contributions from point sources (agricultural and non-agricultural) may have a significant, relatively quick and positive impact on river water quality in some catchments. This could allow time for slower-acting measures aimed at diffuse agricultural losses, such as the GAP measures, to have greater effect.

7. Closed period is effective but extension is not warranted

Concentrations of P in streams reduce during the closed slurry spreading period and don't show pulses of increased losses at the start of the open period as the open slurry spreading period begins. Pulses of high phosphorus concentrations in streams outside the closed period can be linked to losses from manure/slurry spreading due to high-rainfall summer storms.

Policy Relevance

Extending the existing closed period is unlikely to significantly reduce the risk of P loss to water. Additional support for farmers with more timely soil condition and weather information to enable better decisions about timing and location of organic nutrient applications could reduce the likelihood of these incidental losses all year round. In future it may be possible to have real-time updates for farmers based on weather forecasts to support their decision making.

8. Sediment losses are low and from a variety of sources

Irish sediment losses are low by international standards and sources differ between catchments. For example, stream bank and bed erosion and road losses made up most (75% in a poorly drained catchment) for the more common land uses, i.e. grassland in catchments with modified stream channels. Bare soils at vulnerable times of the year are also key sources in other catchments.

Policy Relevance

Targeting of mitigation measures at these specific sediment sources could reduce sediment losses more efficiently than blanket measures. Landscape variability (field sizes/shapes, hedgerows, riparian vegetation and ditches) are likely to offset sediment losses even in vulnerable catchments.

9. Critical Source Areas

Using high resolution digital maps, the ACP has developed a Geographic Information system (GIS) based method for pin-pointing areas in the landscape which are critical in facilitating the loss of nutrients from farmland to water. These electronic maps with a resolution (pixel size) of 1-2m were found to be optimum for capturing the influences of small-scale landscape features on the movement of water at the field scale and for identifying areas where overland flow is more likely, for example along river banks and further upslope. Targeting mitigation measures at these relatively small areas could be an alternative to implementing buffer strips along entire water courses. It was also found that the area of land deemed to be at risk based on soil at P index 4 was significantly reduced and the risky locations changed when compared with this new digital tool.

Policy Relevance

Ultimately, the development and use of a field scale Critical Source Area (CSA) identification package, based on pilot work undertaken by the ACP, could allow real precision in targeting mitigation measures to parts of the landscape where they can be most effective. This approach would minimise any possible impact on farm productivity and help target nutrients to where they will give the best return. The CSA package could be incorporated into nutrient management plans as required by farmers and farm advisors, for derogation and environmental schemes, clearly showing where to take specified actions. Thus it would facilitate sustainable intensification of farming and the operation of schemes in a clear and unambiguous way.

10. Main influencers on farmers' nutrient management practices

Extensive surveys found that the main influencers of farmers' nutrient management decisions, in descending order, were Teagasc advisers, family members, other farmers, the farming press, farm walks and discussion groups. Agencies whose main role is regulatory or commercial have the least influence.

Policy Relevance

This has implications for the dissemination of agri-environmental advice within the Nitrates Regulations and also in regulations where these principles have high importance (such as River Basin Management Plans).

11. Overriding climate and weather pressures on nutrient losses

It was found that measures to mitigate phosphorus and nitrogen losses from land to water are susceptible to influences by large-scale Atlantic weather systems which vary over decades. Excessively wet years and wet pulses following dry periods have become more common patterns during the time that the ACP has been monitoring the six catchments. Ireland may be particularly susceptible due to location, making the potential impact of mitigation measures hard to predict. This has implications for expectations of change and reviews of agri-environmental measures – these measures may be potentially more beneficial in some years and less so in others. These processes also have an overriding influence on water quality metrics such as chemical concentration and chemical load. The extreme variability between and within years, combined with other catchment pressures, means that trend analysis is difficult in the shorter term (and particularly within review periods) as concentration and load will be similarly impacted (with downstream ecological consequences). This is particularly important as source pressures at the other end of the nutrient continuum continue to decline.

Policy Relevance

A full appraisal of how measures are influencing agri-environmental management and impact from source to stream is required and these should not be assessed in isolation. This has implications, for example, for when considering the impacts of changes in the management of N and P source pressures (points 1 and 3 above) and also when considering the influence of transport factors such as soil type, geology, spreading practices and erosion (points 4, 5, 6, 7, 8 and 9 above).

12. Nitrate in groundwater

It was found that average groundwater nitrate levels in all six ACP catchments are well below the World Health Organisation standard of 11.3mg/l of nitrate-nitrogen. However, this threshold can be exceeded occasionally at individual wells in the ACP well network due to localised events but these recover to preceding levels over time.

Policy Relevance

Careful analysis of more coarse resolution groundwater data is important as short term events may provide an unsafe assessment of longer term trends. Short term landuse changes, such as reseeding, as part of normal management should be accounted for.

Phase 3 of the ACP

In Phase 3 of the ACP (2016 – 2019) the team will build on the data collected and the work undertaken in the previous two phases by continuing with the current scientific approach while developing a greater modelling competence. The modelling challenge requires an integrated environmental-economic modelling approach to specifically address the challenges inherent in meeting the production and environmental targets set out for Irish agriculture in Food Wise 2025. The primary aim of the modelling work is to develop the capability to identify the risks to expansion and advise on the overall costs and benefits associated with sustainable intensification practices at field, farm and catchment scale. The large resource which is the existing database built up during the first two ACP phases as well as the data from Phase 3, together with appropriate data from other sources, will be used to best effect to meet this challenge.

In addition, building on the principle of peer-review for reporting ACP findings (and learnings), Phase 3 also aims to deliver an enhanced knowledge exchange (KE) and dissemination programme in collaboration with Teagasc colleagues. The programme will focus primarily on getting key messages from the ACP to farmers mainly via the existing Teagasc KE structures. In addition, it will include dissemination to a wider audience of policy makers, regulators, environmental scientists and the general public through popular media. Given the range and diversity of the audience and the resource constraints that exist an approach that uses all feasible channels will be used to deliver this enhanced dissemination programme.