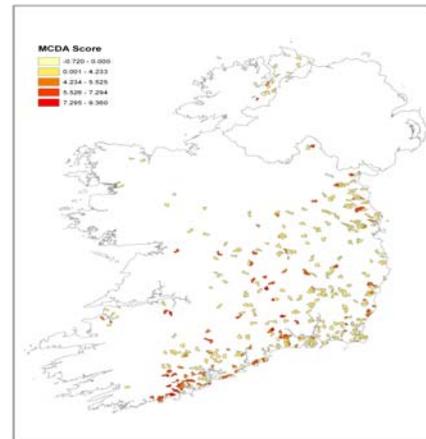**Project number:** 5866
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A novel GIS-based approach for catchment selection in the Irish Agricultural Catchments Programme

Key external stakeholders:

Dept. of Agriculture, Food and Marine, Dept of Environment, Community and Local Government, European Commission, research community

Practical implications for stakeholders:

The developed technique has established a technical framework for identifying experimental catchments and enabled a selection process that is cognisant of agricultural and environmental stakeholder interests.

Key outcomes of this chosen approach for stakeholders include:

- Development of capacity to incorporate expert judgment into a geographical information system (GIS) based selection / classification procedures.
- Provision of a mechanism whereby key aspects of a decision / selection problem in an agri-environmental context can be organised in a hierarchical manner.
- Facilitation of a better understanding of the participating elements in a complex decision making setting enabling transparency in the process.

Main results:

- GIS based application used to ensure compliance with European environmental legislation
- Innovative GIS-multi criteria approach used for optimised catchment selection
- Facilitation of the establishment of the Agricultural Catchments Programme

Opportunity / Benefit:

The main research findings have been used to underpin the Agricultural Catchments Programme by identifying suitable catchments in a scientifically robust, transparent manner. The outcomes have been subject to external peer review and have been approved by the project steering committee as providing a comprehensive, justifiable selection of catchments appropriate to the requirements of the European Commission for establishing monitoring programmes under the framework of the Nitrates Directive.

Collaborating Institutions:

N/A

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External collaborators:	N/A

1. Project background:

The European Union Water Framework Directive and Nitrates Directive are the primary legislative initiatives in place to mitigate the potential for agricultural activities impairing water quality in river basin districts. As part of the requirement for evaluating the Nitrates Directive National Action Programme (NAP) and an associated derogation for intensive grassland farming, Ireland is monitoring environmental and economic effectiveness at the catchment scale. As in other countries, issues around maintaining a high capacity, productive agricultural sector while ensuring a sustainability-based farming approach remain a focus for all stakeholders.

In partnership with farmers and other stakeholders, the Irish Agricultural Catchments Programme (ACP) is mandated to support productive agriculture while protecting water quality. It is funded by the Irish Department of Agriculture, Fisheries and Food and run by Teagasc. ACP advisers provide an intensive advisory and planning service to farmers in small river catchment areas (500 to 2,900 hectares). They help the farmers improve their profitability and implement the necessary agri-environmental measures contained in the NAP.

Prior to establishing a specific experimental design to evaluate the dynamics of agriculturally-derived nutrient transfers, it was necessary to define a landscape scale series of experimental river catchments that are representative of the existing range of principal agricultural enterprises and intensities, and in a variety of environmental settings.

In the work phase described here, which contributed to the main project, a method was developed to select experimental catchments using national spatial datasets in a multi-criteria decision analysis (MCDA) approach implemented in a Geographical Information System (GIS).

2. Questions addressed by the project:

The selection of catchments was subject to EU guidelines that indicated that monitoring efforts be concentrated in "areas of intensive crop and livestock production . . . with elevated nitrate concentrations . . . adjacent to existing or projected eutrophication areas . . . with similar land use, soil type, or agricultural practice."

Specific questions addressed by this project included:
- Could a database of environmental variables of relevance to the catchment selection guidelines be developed?

- Could we develop and implement a method for selecting small catchments (from 400 to 1,200 hectares) with specific criteria? Catchments that were: farmed intensively; either predominantly grassland or arable; and at risk of high phosphorus or nitrogen losses from land into the rivers that drain them.

3. The experimental studies:

Given the spatial and environmental context of the task of candidate catchment selection, the role for a GIS-based methodology was immediately obvious. ArcInfo GIS (ESRI Inc.) was used to build a geodatabase to hold and manage the range of datasets that were required for the task and which were supplied by a diverse group of government departments and agencies.

In beginning the selection process, Spatial Analysis Unit staff first examined a national catchment boundary dataset of approximately 6,000 catchments to generate a list of 1,300 possible small river catchments based on size and Strahler stream order. These were further divided into two broad categories—grassland and

arable cropping. The data analysed included land use, forestry, area of peat, livestock density, non-agricultural land use, arable cropland, forage areas, housing density, geology, and soil types. A Multi-Criteria Decision Analysis (MCDA) approach was employed in the analysis using the onboard attribute table tools already available in an ArcInfo processing environment.

After detailed consultation with a broad range of experts from scientific, policy and farm sector backgrounds, various selection criteria were chosen and given weightings, reflecting the suitability of the catchments for monitoring by ACP. The internal attribute tables of each of these input parameters were reclassified into appropriate ranges and these too were ranked according to selection suitability. A weighted summation provided an ordered list of catchments ranked by their suitability. GIS raster modeling software was used to model the risk at catchment-level of nitrogen or phosphorus moving from land to water. This model implemented a risk assessment procedure devised at national level for formal reporting to the European Commission on Water Framework Directive implementation. The ACP programme had at its disposal the most detailed national scale datasets and the risk model developed for the programme is the most highly resolved available nationally.

The model is primarily based on soil drainage and subsoil hydrological characteristics. Generally, more poorly drained soils have a greater risk of phosphorus loss through overland flow or runoff, while the more freely drained soils have a greater risk of nitrogen loss through leaching down through the soil. Of the 1,300 eligible catchments initially identified, a short list of 50 top-ranking arable and grassland catchments was drawn up. These catchments were visited by ACP staff and assessed for their physical suitability as study sites. Six catchments were subsequently selected for detailed study by ACP; 4 that were predominantly grassland and 2 with a high proportion of arable farming. The GIS-MCDA approach was shown to be particularly suitable to the selection task and its implementation in ArcInfo proved highly efficient in handling the large number of input datasets and processing requirements.

4. Main results:
The selection of six catchments in line with EU requirements and involving engagement with catchment stakeholder communities was a first stage in the evaluation of the NAP in Ireland. The MCDA approach was used to select four working catchments with data-mining of the individual layers to define a fifth in a karst landscape. MCDA was also used to aid in pre-selection of the sixth, grassland-based catchment. Combined, the catchments represent the range of intensive grassland and arable agricultural interests in Ireland across a soil and physiographic gradient that defines potential risk of P and / or N transfers, including regions availing of derogation under the Nitrates Directive. This range includes heavy clay and gleyed soils developed on glacial tills and marine clays; free draining brown earths on poorly productive aquifers; and base rich shallow soils developed on karst limestone plateaux. The hydrological susceptibility and inferred nutrient transport risks used in the process were based on measures of soil and geological permeability and were only applied as P or N risk in the context of a landuse pressure being present.

Four of the finally selected catchments are grassland based with differences in inferred P and N risk depending on the permeability of the soils and range of stocking densities. The two arable catchments are also distinguished by soil permeability with the extent of arable enterprises in each ranging between 30–50% of catchment area.

5. Opportunity/Benefit:
The main research findings have been used to underpin the Agricultural Catchments Programme by identifying suitable catchments in a scientifically robust, transparent manner The outcomes have been subject to external peer review and have been approved by the project steering committee as providing a comprehensive, justifiable selection of catchments appropriate to the requirements of the EU for establishing monitoring programmes under the framework of the Nitrates Directive..

6. Dissemination:

Main publications:
Fealy, R.M., Buckley, C., Mechan, S., Melland, A., Mellander, P-E., Shortle, G., Wall. D. and Jordan, P. (2010).The Irish Agricultural Catchments Programme: catchment selection using spatial multi-criteria decision analysis. *Soil Use and Management* 26: 225-236

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Main Popular publications:

Mechan, S., Burgess, E. & Fealy, R.M. (2010). *Irish Agricultural Catchments Programme Protects Water Quality While Supporting Productive Agriculture.* ArcNews 3293): 34

Shortle, G. (2009). The Agricultural Catchments Programme – innovation for farming and the environment. *TResearch* 4(2) 38-39

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