

Farm Level Actions towards Water Pollution Control: The Role of Nutrient Guidance Systems

Abstract

Enhanced agricultural pollution control will be required to ensure compliance with the 2015 EU Water Framework Directive. Drawing upon data from an on-farm survey with 1370 farmers and growers across England, combined with production, financial, farm and farmer characteristic data from the English Farm Business Survey, this paper investigates farmer attitudes and actions towards water pollution control. Significant differences in practices taken to reduce or prevent pollution were observed by farm type, EU region, farmer education level and use or absence of a nutrient guidance system. However, no significant differences were observed in financial output-input performance of arable farmers by use and non-use of a nutrient guidance system. Nutrient guidance systems were however associated with a greater uptake of practices to reduce or prevent water pollution. Water companies could build upon upstream land management approaches to provide targeted investment in extension services to incentivise on-farm use of these guidance systems.

Key words

Agriculture; Catchment Management; Diffuse Pollution; Environmental Management; Land Use Management; Water Framework Directive

1. Introduction

Increased demand for food driven by population growth (Godfray *et al.*, 2010) will lead to increased agricultural water use (Molden *et al.*, 2010; Pfister *et al.*, 2011; Rockstrom, *et al.*, 2010; Vaux, 2012; Woods, 2000). When coupled with climate change predictions for increasingly volatile and extreme weather patterns and events (Beniston *et al.*, 2007), management of water and pollution control will be of increasing importance. In the EU, water pollution control is regulated by the European Water Framework Directive (WFD) (European Commission, 2000; Gomez-Limmon and Riesgo, 2012); moreover water pollution control is of direct importance to ecosystem services (Rockstrom, *et al.*, 2010). The importance of understanding farmers' perceptions, knowledge, decision making and values towards water, water use and water pollution control has received considerable research attention in both developing (e.g. Mojid *et al.*, 2010 [Bangladesh]; Buechler and Mekala, 2005 [India]; Kijne, 2001 [Pakistan]; Sturdy *et al.*, 2008 [South Africa]) and developed (e.g. Doole, 2012 [New Zealand]; Finger, 2012 [Switzerland]; Gaydon *et al.*, 2012 [Australia]; Medellin-Azuara *et al.*, 2012 [USA]; Scully *et al.*, 2004 [Ireland]) country contexts. Within a UK context studies have also focused upon the impacts of agriculture on water pollution and ecosystem services (e.g. Foy and Kirk, 1995; Neal and Jarvie, 2005; Rigby, 1997), regulatory control (e.g. attitudes towards Nitrate Vulnerable Zones (NVZ) in Scotland; Barnes *et al.*, 2009; 2011; Macgregor and Warren, 2006), source control interventions (SCIs) by water companies (Spiller *et al.* 2013), the importance of agri-environmental schemes in reducing pollutants (Kay *et al.* 2009) and environment consequences for soil and water quality of waste disposal (Towers and Horne, 1997).

The focus of research on pollution control has frequently been in response to regulatory drivers, examining the efficacy, efficiency or economic incentives of particular approaches. Examining the need for more integrated approaches to water management for food production and ecosystem services, de Fraiture *et al.* (2010) note the trade-offs involved in water management and call for new approaches and strategies for the future, while Bartolini *et al.* (2007) find that the costs of implementing the WFD vary substantially across different policies. Doole (2012) finds that least-cost policies, to improve water quality, are those which are differentiated

towards specific farm situations, rather than generic broad-brush approaches. However, these approaches assume an acceptable level of regulatory farm-specific knowledge, combined with a legal framework that would allow farm-differentiated regulations to be implemented (Jolink, 2010). Barnes *et al.* (2011) note that farmers who are more receptive to addressing water issues related to NVZ regulations, are more willing to seek information from advisors and Government. Despite the potential for good water practices to provide financial benefits to individual farmers, Barnes *et al.* (*op cit.*) note that farmers react negatively to NVZ water regulation controls. Indeed, Barnes *et al.* (2009) cite the need for policies which provide 'win-wins' to farmers, with respect to minimising environmental damage, while providing financial or production benefits.

Within a practical UK farming context, pollution control via appropriate input use, can be facilitated via the use of nutrient guidance systems (e.g. RB209 [Reference Booklet 209]; Defra, 2011). The fertiliser recommendation guidance of RB209 (and the computerised version, PLANET [Planning Land Applications of Nutrients for Efficiency and the Environment], Gibbons *et al.*; 2005), sits alongside management guides focused upon animal manure applications – MANNER (Chambers *et al.*, 2000). The role for nutrient guidance systems lies in the potential to achieve efficient nutrient use and minimise negative environmental externalities, for example in the form of reducing nitrate leaching and pathogen release to watercourses, from animal production (Nicholson *et al.*, 2004). The issue of pollution control received considerable attention at the turn of the millennium, with investment and advice from the UK Ministry of Agriculture, Fisheries and Food, to encourage the use of guidance systems (see for example Dampney *et al.*; 2000; Goulding, 2000). However, analysis of the uptake of nutrient guidance system indicates that while consultants and advisers overwhelmingly held copies of RB209, only a fifth noted that it influenced their recommendations (Smith *et al.*, 2009). Moreover, usage of RB209, PLANET and MANNER were noted to be limited to 26%, 10% and 7% of farmers respectively (Smith *et al.*; *op cit.*). While the agricultural community may be sceptical about using decision guides (Gibbons *et al.*, 2005), uptake is influenced by the medium of communication (Goodlass, 2006) and, arguably, will be most effective once a financial benefit flowing from their use has been clearly demonstrated or observed. Kay *et al.*

(2009) noted that clear demonstration of the financial benefits from farmers participating in agri-environmental schemes (featuring nutrient management and water pollution control actions) would encourage uptake, and have a resultant positive effect on reducing water pollution.

The use of nutrient guidance systems provides a key practical mechanism for reducing water pollution. However, there is a paucity of research which seeks to understand, or explain, the linkage between the use of guidance systems on farmer attitudes towards water management. The objective of this paper is therefore to present an analysis of farmer attitudes towards agricultural water management, with a particular focus on the use of nutrient guidance systems as an influence on managerial practice. Section 2 provides the methodological approach adopted in the study and section 3 provides results. Section 4 discusses these results in the context of previous research, while section 5 provides concluding comments.

2. Method

A structured questionnaire was developed, following the approach of previous authors (e.g. Mojid *et al.*, 2010). Data collection used experienced farm survey Research Officers (ROs) from Rural Business Research with the questionnaire embedded within the Farm Business Survey (FBS) research programme for England. Data collection took place from February to October 2010. Data was obtained from 1370 farmers in England, representing a large sample size in comparison to some studies (e.g. Mesa-Jurado *et al.* (2012), 150 questionnaire interviews; Knox *et al.* (2012), 8 case-studies; Barnes *et al.* 2009; 2011, 184 telephone responses; Mojid *et al.* (2010), 416 questionnaire interviews) and comparable to others (e.g. Maraseni and Cockfield, 2012, 1172 observations). The questionnaire sought information on water sources, storage, current and future management practices to reduce or prevent pollution (e.g. use of buffer strips, use of guidance system for nutrient application, reduction in stocking rate when soils are wet), together with the primary reason for taking measures to reduce or prevent pollution (e.g. legislation, environmental, customer). Data on management practices for efficient water use (e.g. recycling, in-field soil moisture measurement, rainwater collection systems), and the primary reason for carrying out water efficient methods (e.g.

financial, environmental), were also recorded. The detailed water questionnaire is available from Defra (2010).

The data from the water questionnaire were combined with a range of data from the FBS 2009/10 financial year main return for participating co-operators (e.g. farm type, EU geographic region, farmer age groupings, education level, agricultural area, financial ratio of agricultural output to input costs). In order to test hypotheses that there is no association between individual farm, or farmer, characteristic groups (farm type, EU region, age, farmer education-level) and uptake of management practices, or intention to undertake future management practices, a non-parametric statistical test required. Chi-Squared is a standard statistical technique to test the hypotheses of no association between groups (e.g. Farm types) and observed outcomes (e.g. use of minimum tillage, testing soil nutrient levels, improved storage of animal wastes); specifically Chi-Squared analysis tests a set of observed outcomes against a set of group-independent expected outcomes. A total of 11 Chi-squared tests were undertaken¹ in Microsoft Excel 2010, testing group *and* outcome combinations (e.g. nine farm types against 12 management practices as reported in Table 1). The underlying assumptions of the Chi-squared test requires that the number of 'expected' data cells (group by outcome) with fewer than five observations is less than 20% of the total expected data cells. Due to this restriction, it was not possible to undertake the Chi-Squared test in a small number of cases. For continuous data a parametric statistical technique is normally appropriate to test the hypothesis of no difference in the mean between two data sets. However, where the continuous data are unlikely to meet the assumptions of a normal distribution, frequently used statistical techniques (e.g. T-test), are in appropriate. Because continuous farm characteristic data (e.g. farm size) are frequently non-normally distributed a non-parametric test is more appropriate. Mann-Whitney U tests provide an appropriate non-parametric statistical technique to test the hypothesis of no significant difference in the mean results between two

¹ Four tests assessed the influence of Farm Type, EU Region, Age, Education, against the range of management practices to reduce or prevent water pollution, while a further four tests examined the influence of Farm Type, EU Region, Age, Education against the group of intentions to undertake additional management practices in the future to reduce or prevent water pollution. Three tests assessed three arable farm types, by presence or absence of use of guidance system for managing nutrient input against the range of management practices to reduce or prevent water pollution.

data sets. Nine Mann-Whitney U tests were undertaken in GenStat (14th Edition) to test the hypothesis that the use, or absence, of a nutrient guidance system on three arable farm types had no influence on utilised agricultural area (UAA) of the farm, percentage of the UAA that was owned, and ratio of agricultural financial output to agricultural cost inputs.

3. Results

3.1 Current practices to reduce or prevent pollution

Table 1 presents results of the percentage of respondents undertaking management practices to reduce or prevent water pollution against farm types, EU region and age and education level of the farmer. *A priori* it would be expected that different management practices would be undertaken by different farm types (e.g. calibration of fertiliser spreaders by 92% [Cereals], 93% [General Cropping], 69.7% [Mixed] farms compared with (*cf.*) 15.3% [Poultry], 23.1% [Pigs], 33.3% [Horticultural] farms), and in turn different EU regions of England, given the regional nature of the majority of farm types. Other aspects worthy of note include the greater proportion of Dairy farm types recording improved storage of animal manures (64.7%) and precision application of livestock manures (30.7%), relative to other livestock farm types, e.g. Pig farm types, respectively recording 40.4% and 15.4%. Dairy farms also recorded the greatest proportion of capital works to reduce pollution of surface water by farm operations (33.5%). In addition to the regional differences following expected farm type observations, it is informative to note that precision application of animal manures is greater in the North (21.3%), than the East (9.5), or West (7.4%). A relatively low proportion of farmers in the North use 6 metre buffer strips, ponds and wetlands to reduce run off and store water (21.1%); while this may be expected to be lower than for the East of England, it is of interest that this is substantially lower than that observed in the West (35.4%). Examining the results of the statistical tests, significant differences in management practices were observed from the two Chi-Squared tests of farm type groups against the range of management practices outcomes, and EU region groups against the range of management practices outcomes.

Significant differences are also observed from the Chi-Squared test of farmer education level groups against the range of management practice outcomes. Relatively greater proportions of

farmers with college or university level education use: 6 metre buffer strips, ponds and wetlands to reduce run off and store water; test soil nutrient levels; and minimum tillage, than observed for the other education groups. Note also that farmers with either School only level education, or those with apprenticeship or other qualifications, record relatively low levels of using a guidance system for managing nutrient inputs (18 to 19%) *cf.* 27-31% for the other three farmer education groups. While no significant differences were observed from the Chi-Squared test for management practices against farmer age groups, it is interesting to note the greater proportion of farmers under 45 years of age undertaking precision application of livestock manures (19.2%), and reducing stocking rate when soils are wet (64.8%); additionally farmers under 55 years of age typically recorded higher proportions of improved storage of animal manures (26-27%).

TABLE 1 HERE

3.2 *Future additional practices to reduce or prevent pollution*

Table 2 shows farmers intentions with respect to undertaking future additional management practices to reduce or prevent water pollution. The lower sample observations for a number of farm types intending to undertake additional management practices led to a high proportion of expected cells within the Chi-Squared test having fewer than five observations, invalidating the statistical test. However, a number of interesting results emerge from the farm type results. Relatively high proportions of Cereal farmers intending to undertake additional management practices (65-70%) plan to use 6 metre buffer strips, calibrate fertiliser spreaders, test soil nutrients and operate minimum tillage. The most frequently observed responses for Dairy farm types include improved storage of animal wastes (61.4%), and capital works to reduce or prevent pollution of surface water by farm operations (35.2%). Calibrating fertiliser spreaders (71.1%) and testing soil nutrients (73.3%) were the most cited intended future practices for General Cropping farms, while testing soil nutrients was the most frequently observed response for Horticulture (50.0%) and Mixed (33.3%) farm types. LFA Grazing Livestock farms cited improved storage of animal wastes highly (54.9%), with Lowland Grazing Livestock farms also noting this intention (32.1%) and keeping livestock out of water courses

(35.7%). Improved storage of animal wastes featured highly for Pig (58.8%) and Poultry (46.2%) farm types, with the former also recording relatively high proportions intending to undertake capital works (41.2%); note however the modest number of observations for the Pig and Poultry farm type groupings. With respect to EU regional variation, statistically significant results are observed, with improved storage of animal wastes featuring strongly in the North (50.0%) and West (36.5%); in the East, use of 6 metre buffers strips (47.0%), calibrating fertiliser spreaders (58.4%) and testing soil nutrients (59.4%) were the most frequently cited. Variations in intended practices by farmer age grouping reveals no significant differences in intentions across the age groups, with interesting results largely restricted to the arguably counterintuitive findings that farmers under 45 years of age recorded the lowest proportion of intentions to undertake capital works (18.8%) and farmers of 65 and over recorded the greatest proportion intending to undertake precision application of livestock manures (14.1%); note however that this latter result represents a relatively small number of the overall age grouping. Significant differences in the farmer education level groupings are observed, with improved storage of animal wastes a strong feature of apprenticeship or other (66.7%), School only (36.1%) and GCSE or A-level education (40.5%) groupings. Testing soil nutrients was the most frequently observed intention within the College (37.5%) and undergraduate / postgraduate (46.5%) education groupings.

TABLE 2 HERE

3.3 Influence of nutrient guidance system on practices to reduce or prevent pollution

Results in Table 1 show that the use of guidance system for managing nutrient inputs (e.g. RB209, PLANET) is most frequently observed in the Cereals (43.3%), General Cropping (50.0%) and Mixed (36.7%) farm type groupings. Typically, these three farm type groupings represent the arable farm type groupings within the FBS. Given that there remain a large proportion of farmers within these arable farm type groups that do not follow a guidance system it is instructive to examine the management practices associated with those farmers that do, and do not, follow a guidance system as shown in Figure 1. A consistent pattern is observed across the three farm types in Figure 1A greater proportion of farmers using a

guidance system within each farm type grouping undertake the following actions: use 6 metre buffers strips (45.0-67.4% *cf.* 36.2-62.5% for those not following a guidance system); undertaken capital works to reduce pollution of surface water from farm operations (14.0-28.3% *cf.* 8.8-10.8%); calibrate fertiliser spreaders (85.0%-98.2% *cf.* 60.9-90.0%); test soil nutrients (85.0-97.8% *cf.* 63.8-88.3%), operate minimum tillage (37.5%-68.5% *cf.* 11.6-45.0%); disrupt tram lines (45.0-64.9% *cf.* 21.1-32.5%); and undertake precision application of livestock manures (15.2-22.5% *cf.* 2.5-7.0%). Significant differences are observed within the Cereals ($p < 0.01$) and General Cropping ($p = 0.063$) farm types, while no significant differences are observed within the Mixed farm type grouping by use and non-use of a guidance system.

FIGURE 1 HERE

3.4 Farm structural and agricultural financial performance: influence of use of a nutrient guidance system

The utilised agricultural area (UAA) (Figure 2) on farms that use a guidance system is significantly greater than the UAA on farms that do not use a guidance system for Cereals ($p = 0.041$) and General Cropping ($p = 0.009$) farm types at the 95% significance level, and at the 90% significance level for Mixed farms ($p = 0.080$). However, there is no significant difference in any of the three farm type groupings by use of guidance system for percentage of the UAA that is owned by the farmer (Figure 3), nor the ratio of agricultural output revenue to agricultural costs. Note that the average agricultural output to agricultural input return is less than 100%, indicating that on average across the farm type groups presented, and irrespective of use of a guidance system, the returns to agricultural activity were lower than the costs of production.

FIGURES 2 and 3 HERE

4. Discussion

With respect to management practices to reduce or prevent pollution, significant differences in farm type and EU region were observed, in part reinforcing *a priori* expectations with respect

to the importance of different practices for particular farm types. Results within this study show that farmers with higher levels of education were associated with undertaking more practices to reduce or prevent pollution. This finding contrasts with Barnes *et al.*'s (2011) analysis in Scotland which identified that farmers with higher levels of education, who were younger, or were farming a larger area, were more likely to be categorised as "resistors" of measures or practices to reduce water pollution. Hence, across these two studies no consistent finding emerges with respect to the impact of education on the uptake of practices to reduce pollution.

In addition to the education level of the farmer, which is typically categorised as a biographical managerial *characteristic* (Wilson *et al.*, 2001), managerial *practices*, in this context observed via the use / non-use of a nutrient guidance system, were also observed to influence management practices towards preventing or reducing water pollution on Cereals farms. Previous studies have identified the importance of 'management', particularly as a determinant of technical efficiency in agricultural production (Wilson *et al.* 1998; 2001), and 'information seeking' as a characteristic of willingness to engage in water pollution control (Barnes *et al.*, 2011); the results presented herein also indicate that such differences in managerial practices influence attitudes towards pollution control. Contrasting with Barnes *et al.* (2011), this study found that farmers using a guidance system were more likely to be farming a larger agricultural area. The results presented herein indicate that 9-50% of farmers, defined by farm type groups, follow a guidance system for managing nutrient inputs, in line with previous findings (Gibbons *et al.*, 2005). Previous authors have noted that there is considerable scope to reduce water pollution via adherence to regulations, simultaneously enhancing agricultural financial performance (Barnes *et al.*, 2011); however, no significant differences in agricultural financial performance were observed within farm type groups differentiated by use or non-use of a guidance system from this present study. The uptake of guidance systems has also been noted to be dependent upon the medium of communication used (Goodlass, 2006). Further potential avenues for reducing or preventing pollution control include increasing the use of, or enhancing the water quality aspects within, agri-environmental schemes (Kay *et al.* 2009), or by a reassessment of the EU 'polluter pays' principle, to allow water companies to engage in SCIs

which include payments to farmers for pollution control management activities (Spiller *et al.*, 2013). The use of SCIs for pesticide and nitrate pollution control has been previously argued to offer potential for water companies and farmers to work together. Agri-environmental schemes, in particular 'higher level' agri-environmental schemes, feature management actions that reduce pollution to water courses; a key feature of these often being enhanced storage, management and application of nutrients to fields (Kay *et al.*, 2009). However, Evans (2012) argues that targeting farmers and land owners alone will not be sufficient to address water quality issues, and that combined approaches with water companies will be required. Nimmo Smith *et al.* (2007) contrast the approaches between Denmark and England with respect to NVZ regulatory enforcement and note the potential for reducing nitrate losses in England via wider spread use of nutrient guidance systems. Given the field, farm and catchment specific nature of issues affecting water pollution control (Kay *et al.* 2009; Doole, 2012), the need for compliance with the WFD by 2015, and the potential economic benefits from more appropriate application of nutrients, there is a strong argument for further incentivising the use of nutrient guidance systems. Water companies could therefore provide more targeted investment in agricultural extension services, working on a farm-by-farm basis, to expand the use of these guidance systems as a direct SCI strategy, including paying farmers to use nutrient guidance systems. Such developments would build upon current initiatives of water companies seeking to improve water quality through land management approaches (e.g. South West Water, 2013; 'Upstream Thinking'), whereby water quality is managed at source, and be complementary to schemes such as Catchment Sensitive Farming (Natural England, 2013). Within the context of using SCI as optimal pollution control approaches, Joosten *et al.* (1998) propose a combined farm-level - water company decision-support system in the Netherlands. Considered at the landscape-scale, Joosten *et al.*'s (*op cit.*) proposal requires co-operation amongst farmers, in contrast to use of farm-level guidance systems, which negate the potential barriers brought about by the need for farmer-farmer co-operation. Lichtenberg and Zimmerman (1999) find that in the USA, farmer behaviour and attitudes towards the environment are influenced by information sources, noting that those farmers placing greater emphasis on independent evidence express more concern about the environment; the impartial nature of nutrient

guidance systems, in contrast to information from fertiliser or pesticide companies, could therefore offer potential gains with respect to farmer behaviour change. Aarts *et al.* (1999) note the potential for providing financial support to dairy farmers in the Netherlands to reduce water pollution; however, they additionally note the need for support systems to facilitate the adaptation of farming practices to meet environmental goals. Given the evidence from both this present study and previous research, incentivising farm-level guidance or support system use is argued to offer a direct SCI strategy with considerable scope for embedding enhanced water pollution control activities in commercial agricultural contexts. However, future research that explicitly examines the potential for uptake of similar guidance systems in a wider geographic context would facilitate more direct comparison with the findings presented herein.

5. Conclusion

The control of pollution to water courses represents a key issue for agriculture. This study has found that the practices to reduce or prevent water pollution in England vary significantly across farm type groups as would, *a priori*, be anticipated. Moreover, significant differences in practices were also observed across EU region and farmer education groupings. On arable farm type groupings, significant differences were observed with respect to practices to reduce or prevent pollution by the presence or absence of the use of a nutrient guidance system, however, no significant difference in agricultural financial performance was identified between these two nutrient guidance system usage groups. Previous evidence and that presented herein indicates that the use of a nutrient guidance system is associated with a greater uptake of practices to reduce or prevent water pollution. The lack of clear financial benefit from nutrient guidance systems represents a challenge for achieving additional uptake of their use. However, water company-funded farmer extension services offer potentially cost effective mechanisms for the control of water pollution from agriculture. .

Acknowledgements

The author thanks the farmers and growers who participated in this study for freely giving their time and sharing information on their production practices. Thanks are also due to the Research Officers of Rural Business Research for undertaking the data collection and to Defra for the financial support for the data collection element of this research. The views expressed herein do not represent Rural Business Research or Defra. Any errors or omissions are the responsibility of the author alone.

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Table 1: Percentage of respondents undertaking management practices to reduce or prevent water pollution by individual Farm Type, EU Region, Age and Education groupings

	Management Practice	Observations													
		None	Use 6 metre buffer strips, ponds, and wetlands to reduce run off and store water	Capital works to reduce pollution of surface water by farm operations	Calibrating fertiliser spreaders	Testing Soil Nutrient levels	Minimum tillage	Disrupt tramlines	Precision application of livestock manures	Follow a guidance system for managing nutrient input (e.g. RB209, PLANET)	Reduce stocking rate when soils wet	Keep Livestock out of water courses	Improved storage of animal wastes		
Farm Type**	C	212	2.4	64.6	18.4	92.0	92.5	55.2	45.3	8.0	43.4	27.4	16.0	3.8	
	D	218	0.9	30.3	33.5	58.3	53.7	4.6	13.3	30.7	30.3	90.8	59.6	64.7	
	GC	114	2.6	55.3	11.4	93.0	88.6	35.1	43.0	10.5	50.0	23.7	16.7	5.3	
	H	147	38.8	21.8	9.5	33.3	44.9	8.8	8.2	1.4	23.1	2.7	3.4	0.0	
	LFAGL	202	12.4	11.9	21.8	39.1	23.8	0.5	1.5	10.4	9.4	83.2	23.3	20.8	
	LGL	242	10.7	26.4	22.7	39.3	33.5	5.4	5.4	10.3	14.0	81.8	44.2	18.2	
	M	109	1.8	39.4	16.5	69.7	71.6	21.1	32.1	11.9	36.7	78.0	45.9	19.3	
	PG	52	30.8	13.5	15.4	23.1	26.9	9.6	9.6	15.4	13.5	21.2	19.2	40.4	
	PTY	59	40.7	13.6	16.9	15.3	16.9	8.5	8.5	3.4	13.6	13.6	16.9	23.7	
EU Region**	North	394	10.9	21.1	24.9	56.1	41.9	7.6	11.9	21.3	19.5	69.0	27.2	29.4	
	East	568	14.8	39.1	13.7	59.2	60.0	26.8	26.2	9.5	30.5	34.5	23.1	11.8	
	West	393	8.4	35.4	24.9	48.6	52.2	11.5	13.0	7.4	27.0	73.5	44.3	29.0	
Age (years) ^{ns}	<45	193	9.8	31.6	19.2	57.0	48.7	13.0	18.7	19.2	26.4	64.8	31.1	26.9	
	45-54	416	12.3	32.9	22.4	55.5	53.4	19.5	16.8	10.6	27.6	57.5	32.7	26.2	
	55-64	461	12.1	34.1	18.9	54.9	54.2	16.9	16.5	10.8	26.0	53.8	29.5	18.4	
	65+	285	11.9	31.2	20.0	54.0	50.9	15.1	22.8	12.6	24.6	50.9	28.1	17.9	
Education**	Sch	393	14.5	26.5	19.8	49.6	47.3	9.9	11.7	10.4	18.8	60.1	30.3	18.3	
	GC/A	229	9.6	31.4	24.5	59.8	49.3	14.8	19.2	10.5	30.6	58.1	32.3	21.4	
	Coll	469	12.4	37.1	17.9	59.7	56.5	20.5	23.2	14.7	30.5	53.7	30.9	25.6	
	UgPg	226	15.5	37.2	19.5	51.3	57.1	25.2	20.8	12.4	27.4	47.3	27.4	18.1	
	Ap.Ot	38	7.9	26.3	31.6	52.6	47.4	2.6	2.6	13.2	18.4	76.3	31.6	39.5	

Key: Farm Types: C-Cereals; D-Dairy; GC-General Cropping; H-Horticulture; LFAGL-Less Favoured Area Grazing Livestock; LGL-Lowland Grazing Livestock; M-Mixed; PG-Pigs; PTY-Poultry. Education: Sch-School only; GC/A-GCSE or A-levels; Coll-College/National Diploma/Certificate; UgPg-Undergraduate Degree or Postgraduate Qualification; Ap.Ot-Apprenticeship or Other. ** Statistically significantly different at 99% or above. ^{ns} no statistical significant difference.

Table 2: Percentage of respondents intending to undertake additional management practices in the future to reduce or prevent water pollution by individual Farm Type, EU Region, Age and Education groupings

Future Management Practice		Observations	Percentage of those responders intending to undertake one or more additional management practice										
			Use 6 metre buffer strips, ponds, and wetlands to reduce off and store water	Capital works to reduce pollution of surface water by farm operations	Calibrating fertiliser spreaders	Testing Soil Nutrient levels	Minimum tillage	Disrupt tramlines	Precision application of livestock manures	Follow a guidance system for managing nutrient input (e.g. RB209, PLANET)	Reduce stocking rate when soils wet	Keep Livestock out of water courses	Improved storage of animal wastes
Farm Type [‡]	C	84	66.7	15.5	69.0	69.0	65.5	41.7	4.8	25.0	9.5	7.1	7.1
	D	88	4.5	35.2	8.0	5.7	1.1	1.1	21.6	8.0	5.7	6.8	61.4
	GC	45	46.7	11.1	71.1	73.3	46.7	33.3	4.4	44.4	6.7	8.9	8.9
	H	30	30.0	16.7	36.7	50.0	6.7	10.0	0.0	43.3	6.7	3.3	0.0
	LFAGL	51	2.0	33.3	2.0	11.8	0.0	0.0	2.0	3.9	3.9	19.6	54.9
	LGL	56	7.1	30.4	7.1	17.9	7.1	3.6	7.1	7.1	19.6	35.7	32.1
	M	36	25.0	30.6	25.0	33.3	25.0	13.9	16.7	22.2	30.6	27.8	27.8
	PG	17	5.9	41.2	11.8	11.8	0.0	0.0	5.9	5.9	5.9	11.8	58.8
	PTY	13	30.8	23.1	23.1	15.4	23.1	30.8	0.0	23.1	0.0	7.7	46.2
EU Region**	North	122	5.7	25.4	4.1	13.9	4.9	1.6	11.5	4.1	0.8	10.7	50.0
	East	202	47.0	18.8	58.4	59.4	40.1	28.2	6.9	32.7	18.3	14.9	19.8
	West	96	7.3	41.7	4.2	6.3	8.3	6.3	9.4	8.3	5.2	17.7	36.5
Age (years) ^{ns}	<45	66	21.2	18.2	27.3	33.3	21.2	16.7	6.1	25.8	13.6	21.2	28.8
	45-54	144	25.2	32.4	30.9	34.5	23.7	12.2	8.6	15.8	6.5	10.8	38.8
	55-64	132	27.3	25.0	34.1	35.6	24.2	17.4	7.6	16.7	11.4	13.6	29.5
	65+	78	30.8	24.4	26.9	33.3	20.5	17.9	14.1	23.1	12.8	16.7	30.8
Education**	Sch	108	13.9	25.0	14.8	22.2	15.7	6.5	5.6	8.3	8.3	13.0	36.1
	GC/A	74	25.7	21.6	29.7	33.8	21.6	14.9	10.8	20.3	5.4	10.8	40.5
	Coll	152	27.6	28.3	35.5	37.5	23.7	17.8	10.5	19.1	14.5	19.7	27.6
	UgPg	71	43.7	26.8	42.3	46.5	35.2	28.2	8.5	35.2	11.3	9.9	21.1
	Ap.Ot	15	13.3	26.7	33.3	26.7	6.7	0.0	6.7	6.7	0.0	6.7	66.7

Key: Farm Types: C-Cereals; D-Dairy; GC-General Cropping; H-Horticulture; LFAGL-Less Favoured Area Grazing Livestock; LGL-Lowland Grazing Livestock; M-Mixed; PG-Pigs; PTY-Poultry. Education: Sch-School only; GC/A-GCSE or A-levels; Coll-College/National Diploma/Certificate; UgPg-Undergraduate Degree or Postgraduate Qualification; Ap.Ot-Apprenticeship or Other. ** Statistically significantly different at 99% or above. [‡] unable to undertake Chi-Squared test due to >20% of expected cells with <5 observations.