Behaviours in relation to diffuse pollution: the relation between awareness and uptake of measures

Authors: Paula Novo[1], Julia Martin-Ortega[2] and Murat Okhuma[2]
[1] Social, Economic and Geographical Sciences Group, The James Hutton Institute
[2] Sustainability Research Institute, School of Earth and Environment, University of Leeds

Delivered as part of RESAS 1.2.4 Objective 2.1 Deliverable D2.1 Analysing how information and awareness affect behaviours with relation to diffuse pollution

March 2017

Executive summary

Diffuse pollution remains a major global problem threatening the health and resilience of social-ecological systems. Failure to tackle diffuse pollution has resulted in the development of new approaches, many of which rely on awareness raising and advice to foster behavioural change. The Scottish Government has been a pioneer in this with the development of the Priority Catchment Approach, which is integrative in nature, context-specific and represents a transition from 'punitive' to an 'advice centred' approach. The aim of this study is to assess whether farmer awareness affects behaviour regarding diffuse pollution mitigation measures. Quantitative methods were employed to analyse SEPA Geofield survey data collected from 1995 farmers across 13 catchment areas in rural Scotland. The study suggests that although awareness has the potential to influence farmer behaviour, awareness alone does not always result in improved compliance. The results do prove that awareness is linked to some practices, such as soil testing and nutrient budgeting, which in turn influence compliance. In this regard, encouraging practical 'hands on' approaches may potentially be a useful approach for further improving regulatory compliance to tackle water quality problems. Future research to unpack how these factors affect farmers' behaviour within each context is recommended.

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1. Introduction

Diffuse pollution affects the capacity of water bodies to provide ecosystem services and it diminishes the resilience of socio-ecological systems (Paterson et al., 2013). Managing diffuse pollution in catchments is therefore important not just for water quality and water security, but also for building systems' capacity to adapt to change (Walker et al., 2004). Significant efforts and resources have been and continue to be deployed in the mitigation of rural diffuse pollution through regulatory, guidance and voluntary measures. Despite these efforts, rural diffuse pollution remains a persistent problem (UN-Water, 2011; OECD, 2012); with, for instance, 38% of the water bodies of the European Union being significantly affected by it (UN-Water, 2015). This failure to produce more significant results is to be mainly attributed to the complexity of the problem (von Korff et al., 2012; Patterson et al., 2013).

Different strategies have been used to mitigating rural diffuse pollution (McGonigle et al., 2012). Approaches have evolved from a focus on single strategies to the use of complementary mechanisms, such as a mixture of economic incentives in the form of taxes and/or subsidies environmental regulations or farm advice and information provision (Macleod et al., 2007; Vrain and Lovett, 2016). In Scotland, the Scottish Environment Protection Agency (SEPA) has established a Diffuse Pollution Management Advisory Group (DPMAG) that 'focuses on protecting and improving Scotland's water environment by reducing rural diffuse pollution'. DPMAG has a two tiered strategy approach to reduce diffuse pollution. First, it includes a national campaign to improve the status of water bodies and prevent further deterioration if required according to the European Union's Water Framework Directive. To support this, DPMAG has developed a national awareness campaign, with specific focus on promoting awareness and ensure compliance with diffuse pollution General Binding Rules (GBRs)[1], which provide a statutory baseline of good practice and their implementation. Second, DPMAG has implemented a targeted approach in fourteen priority catchments where diffuse pollution represents particularly a problem. SEPA has appointed catchment coordinators to investigate the fourteen priority catchments, to liaise with land managers to implement the measures to improve disuse source pollution. The catchment coordinators focus on the priority catchments through a range of workshops and one-to-one farm visits to provide information to land managers about the steps they require taking to improve water quality.

This report provides evidence on the effect of awareness on land managers' behaviour in relation to mitigation measures that are part of the Diffuse Pollution General Binding Rules (GBRs). GBRs are a set of mandatory rules for pollution control in specific low risk activities, as defined in 'The Water Environment (Controlled Activities) (Scotland) Regulations 2011'. We use data gathered by SEPA during the farm visits. The analysis of this dataset represents

[1] http://www.sepa.org.uk/media/37557/rural-diffuse-pollution-plan-scotland.pdf

a novel opportunity to inform policy making about the roles of farmer attitudes and behaviour on land management and water quality impacts.

2. Awareness and behaviour change: overview of the literature

Different theories have been used to explain behavioural change and the factors that influence behaviours (Prager, 2012; Blackstock et al., 2010; Michie et al., 2008). In this section, we explore persuasion theory and the theory of reasoned action and planned behaviour focusing on the role of information, knowledge and awareness in relation to pro-environmental behaviour. We also provide an overview of the literature focusing on behaviour in relation to rural diffuse pollution mitigation.

Persuasion theories suggest that targeted information and advice leads to changes in attitudes that translate into behavioural changes (Prager, 2012; Hovland et al., 1953). Literature suggests that effective persuasion is contingent on three key elements: credibility or trustworthiness of the source, power of the message and receptiveness of the audience or target. Persuasion theory assumes that actors' behaviour is explained by some 'information deficit' that results in a lack of awareness and knowledge about the right strategies to tackle problems (Kollmuss and Agyeman, 2002). Therefore, the model prescribes information provision as the trigger of attitudinal and behavioural changes. However, this model has been criticised as evidence shows that information provision does not necessarily leads to attitudinal and/or behavioural change (Kaiser et al., 2010) and changes in behaviour can take place without changes in attitudes (Prager, 2012). In addition, persuasion models assume that individuals have the capacity to make use of the information. However there might be financial, skills or cultural constraints preventing the actual use this information (Kolmuss and Agyeman, 2002). Research has shown that in addition to the persuasiveness of the message, these other factors play a key role in enabling behavioural change (Novo et al., 2015).

The theory of reasoned action and planning behaviour attempts to address some of the weaknesses of persuasion theory. These theories look at 'intentions to behave' under the argument that change in intentions would lead to change in behaviours. The theory of reasoned action (Ajzen and Fishbein, 1980) suggests that attitudes (toward a certain behaviour) and subjective norms (normative beliefs about the behaviour) shape behavioural intentions and, in turn, behaviour (Madden et al., 1992). Information affects behaviour through changes in attitudes and/or subjective norms. The theory of planned behaviour (Ajzen, 1985) extends the theory of reasoned action by incorporating actors' perceived behavioural control of performing a certain behaviour as a variable affecting intentions and behaviour. Although these theories are widely use in the environmental behaviour literature, a large body of literature points out to the gap between intentions and actual behaviour and the biases when predicting behaviours from intensions (Kaiser et al., 2010;

Jackson, 2005; Kollmuss and Agyeman, 2002). These models often fail to provide a clear understanding of the cognitive, normative and affective facets of human behaviour (Jackson, 2005).

In relation to uptake of measures to reduce diffuse pollution, the literature shows that although awareness and information provision influences pro-environmental behaviour, this may be contingent on the ability and reputation of advisors, levels of understanding and skills, among other factors (Vrain and Lovett, 2016; Vrain et al., 2014, Blackstock, 2007). Vrain et al. (2014) show that farmers who received constant specific farm advise are more likely to take up diffuse pollution mitigation measures, particularly where messages are coherent and understandable and where breaches may result in sanctions. One-to-one approaches are generally considered more effective at delivering messages and encouraging uptake of advises (Blackstock, 2007). On the opposite, where written messages were sent across, farmers often failed to pay attention to most of them, particularly where farmers felt that the senders were bombarding with too much information.

Although environmental awareness is expected to positively influence attitudes, intentions and lead to pro-environmental behaviour, empirical research has showed that other factors such as financial costs, time and labour availability, farming system and farm size as well as the complexity of regulatory policies or measures play a key role in shaping behaviour (Environment Agency, 2014; Vrain et al., 2014; Blackstock et al., 2010; Deasy et al., 2010).

3. Scotland's Priority Catchment Approach

This section summarises Scotland's approach to tacking rural diffuse pollution. It is worth noting that diffuse pollution remains one of the major causes of poor water quality in Scotland (Christen et al., 2015; DPMAG, 2015; SEPA, 2014). Eighteen percent of water bodies in the Scotland river basin district have been classified as having less than good quality attributable to diffuse pollution (DPMAG, 2015). The leading diffuse pollutants include phosphorus, faecal pathogens, nitrates and pesticides from agriculture and related activities (e.g. forestry and septic tanks) that affect the quality of rivers, bathing waters and groundwater.

These major impacts of diffuse pollution have resulted in the development of measures to mitigate diffuse pollution through multiple routes such as regulation, economic support and catchment management initiatives. One of such efforts derived from the development of the River Basin Management Plans published in 2009 which gave priority to mitigating diffuse pollution. The goal was to "improve from 63% of water bodies in Scotland at good status to 97% by 2027" and this was to be achieved through the implementation of the Diffuse Pollution Management Strategy (DPMS) for Scotland – a two tier approach of reducing diffuse pollution (DPMAG, 2015).

The DPMS for Scotland concurrently implements the priority catchment approach and the national approach. While the national campaign involves providing general recommendations, raising awareness, guidance, training and inspections in relation to the impact of diffuse pollution, the priority catchment approach targets specific land managers in priority catchments through one-to-one farm visits. Visits aim at providing guidance to farmers regarding the implementation of diffuse pollution mitigation measures under three regulations: the diffuse pollution General Binding Rules (GBRs), the silage, slurry and agricultural fuel oil (SSAFO) Regulations and the voluntary measures contained in the Scottish Rural Development Plan (SRDP).

Although both the GBRs and SSAFO regulations are compulsory, there is some level of flexibility regarding the uptake and implementation of the GBRs. This is because the GBRs provide control over certain low risk activities whilst the SSAFO regulations check high risk activities associated with silage, slurry and agricultural fuel oil. In addition, agri-environment measures are voluntary and non-binding, however, their implementation may contribute to reducing diffuse pollution from agriculture and related activities (see Martin-Ortega and Holstead, 2013; SEPA, 2013; Scottish Executive, 2005).

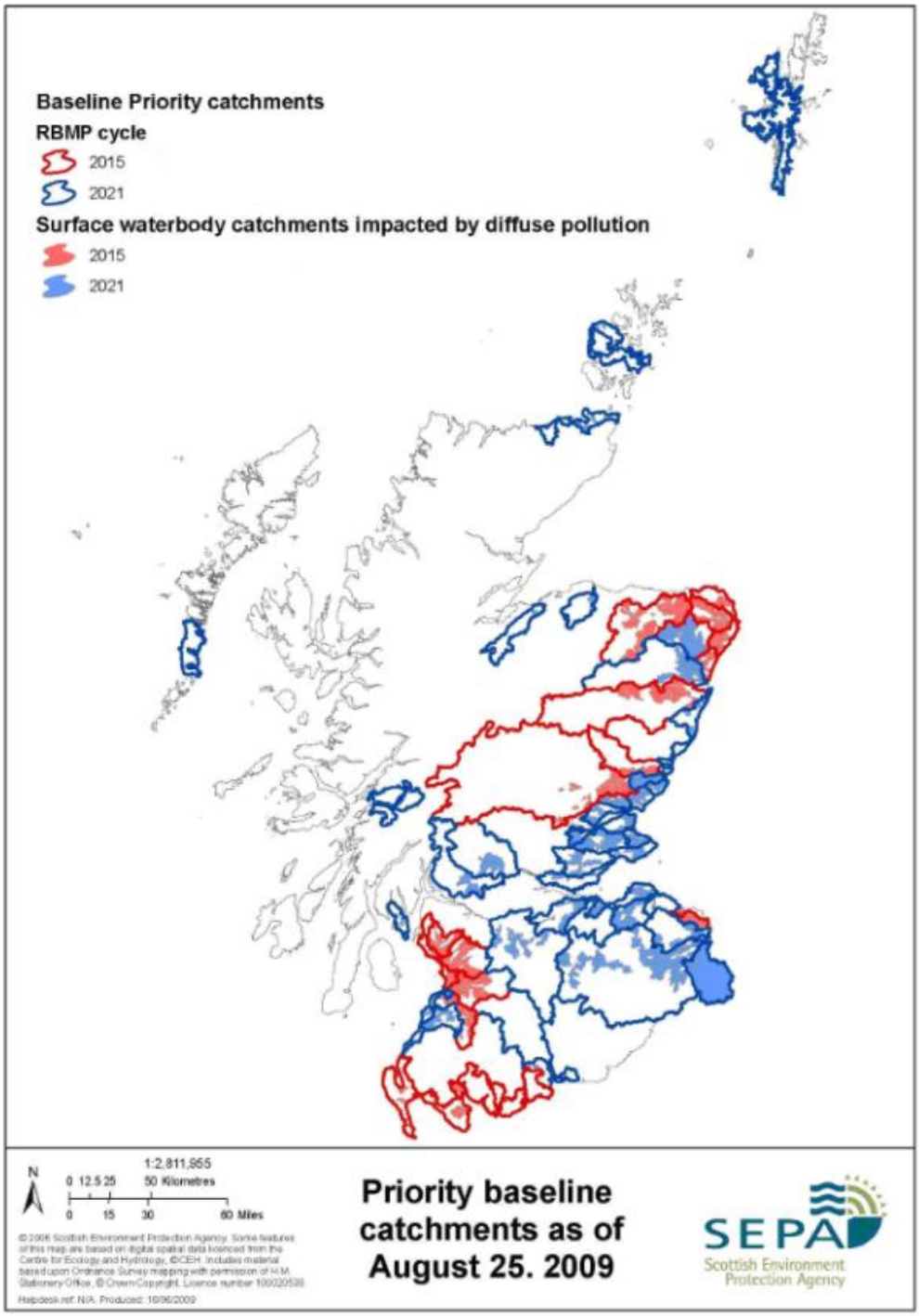
The priority catchment approach is a novel approach in the area of diffuse pollution management. It represents a 'package' that tries to tackle the gaps of earlier approaches, with a focus on advice provision and one-to-one exchanges. Periodic assessments are carried out by SEPA through the collection of relevant information. The information is collected through one-to-one farm visits where GeoField SEPA survey is used to gather information about compliance digitally. GeoField SEPA is a map-based application that allows SEPA to record features of interest such as the location of General Binding Rule breaches, the presence/absence of fencing and socio-economic characteristics, among others. This information is then used to provide advice on what type of measures land managers should take to reduce diffuse pollution or potential risks.

The above description of the priority catchment approach demonstrates a transition from purely 'punitive' approach to 'advise-centred' and targeted approach with emphasis on raising awareness and working with the farmer (Novo et al., 2015). As the approach emphasises awareness raising, context specific information, coordination of efforts and allows a considerable level of flexibility, it seems a promising tool for tackling a wicked problem such as diffuse pollution (Duckett et al., 2016; Patterson et al., 2013).

Under the priority catchment approach, catchment areas were selected across the country. However, priority was given to areas affecting human health (i.e. for conservation, drinking water, bathing and fishing) according to European legislation (DPMAG, 2015). Fourteen areas were selected for the first cycle, spanning between 2009 and 2015 (see Map 1 and

Table 1 for the 14 diffuse pollution priority catchments included in the first cycle as well as those proposed for the second and third cycles).

Map 1. Priority catchments in Scotland 2009 – 2015 and proposed catchments 2015 – 2027.



Source: DPMAG (2012)

Table 1. Diffuse Pollution Priority Catchments for the First Cycle

	Priority Catchment Name
1	Buchan Coastal
2	Eye Water
3	Galloway Coastal
4	North Ayrshire Coastal
5	River Ayr
6	River Dee (Grampian)
7	River Deveron
8	River Doon
9	River Garnock
10	River Irvine
11	River South Esk (Tayside)
12	River Tay
13	Stewartry Coastal
14	River Ugie*

Note: * River Ugie was not part of the database hence this study looks at 13 catchment areas. Source: Adapted from DPMAG (2015)

4. Data and methods

The survey data used in this study was collected by SEPA using GeoField SEPA survey. Through one-to-one farm visits, SEPA gathered data from 1995 farmers across 13 catchment areas (see Map 1 and Table 1). The database includes information about breaches in compliance with GBRs and SSAFO, potential risk of breaches and background information on farmers' self-reported awareness of GBRs, involvement in environmental schemes and whether any soil testing and/or nutrient budgeting is carried out. Most data was collected by asking farmers directly, except compliance and potential risks that were tracked with GPS and observed on-site. Table 2 below describes the main variables used for the purpose of this study. It should be noted that although observations are at farm level, SEPA anonymised the information and therefore we cannot identify specific farms.

Table 2. Main variables used in the study

Variables	Description and values of variables
Catchment	Catchment where the farm is located (see Table 1)
Farming type	Type of farming: 1) arable only; 2) livestock only and 3) mixed farming
Drainage system	Drainage system at the farm: 1) full; 2) partial; 3) no drainage; 4) unknown
Awareness	Whether a farmer is aware (=1) of the Diffuse Pollution GBRs or not (=0).

Soil testing	Whether farmer carriers out (=1) or not (=0) soil testing
Nutrient budgeting	Whether farmer carriers out (=1) or not (=0) nutrient budgeting
Involvement in Agri-Environmental schemes	Whether farmer has been (=1) or not (=0) involved in any agri-environmental scheme
GBRs and SSAFO compliance	Number of non-compliances per measure at farm level
Potential risks	Presence (=1) or absence (=0) of observed risks (e.g. absence of fencing) of the farmer not complying with any of the GBRs on one or more of the farm sites

Source: based on SEPA Geofield survey

Descriptive statistical analysis was performed and inferential methods were also used to identify key relationships between the study variables. Data was analysed using non-parametric statistics.

5. Results

5.1. Farm characteristics

Table 3 summarises the main characteristics of the farms included in the database, namely catchment location, farm type and drainage system.

Table 3. Number (percentage) of farms and farming system per Priority Catchment

	Priority Catchment Name	N (%) farmers	N farmers per farm type		
			Arable	Livestock	Mixed
1	Buchan Coastal	222 (11.1)	21	34	121
2	Eye Water	51 (2.6)	8	9	32
3	Galloway Coastal	150 (7.5)	2	89	30
4	North Ayrshire Coastal	65 (3.3)	3	33	25
5	River Ayr	52 (2.6)	0	29	11
6	River Dee (Grampian)	193 (9.7)	20	33	122
7	River Deveron	268 (13.4)	22	39	192
8	River Doon	51 (2.6)	0	26	11
9	River Garnock	134 (6.7)	2	63	11
10	River Irvine	108 (5.4)	0	39	42
11	River South Esk (Tayside)	114 (5.7)	29	3	46
12	River Tay	433 (21.7)	102	26	173
13	Stewartry Coastal	154 (7.7)	0	102	14
14	River Ugie*	--	--	--	--

Table 3 shows that most farmers included in the one-to-one visits were located in the Buchan Coastal, River Deveron and River Tay catchments, with Eye Water and River Doon having the smallest proportion in the sample. In addition, out of 1564 observations[2], 53% of farms had a mixed farming system, 34% livestock and 13% an arable farm. When looking at catchment level, this distributional pattern does not hold for most of the catchments. Thus, livestock systems predominated in Galloway Coastal, North Ayrshire Coastal, River Ayr, River Doon and River Garnock. In the River South Esk and River Tay catchments arable farming systems were proportionally higher than in the other catchments. A chi-square test of independence confirmed that the observed differences in farm type across catchments are significant. Hence certain types of farming systems are more likely to be observed in certain catchments. Such spatial or regional variation in farming type may be due to dissimilarities in the geology, soil type, etc. within these locations (Vrain et al., 2014).

Table 4 present the drainage system per Priority Catchments. Fully drainage systems were present in 50% of the observations, followed by partially drained (42%), unknown drainage systems (6%, i.e. respondents didn't know the existing drainage type) and not drained lands (2%). Again a chi-square test of independence suggests that observed differences in drainage systems across farm types are significant.

Table 4. Drainage system (N farms) per Priority Catchment

	Priority Catchment Name	Drainage system			
		Fully	**Partial**	**Not drained**	**Unknown**
1	Buchan Coastal	96	76	3	3
2	Eye Water	13	24	5	7
3	Galloway Coastal	53	65	3	12
4	North Ayrshire Coastal	39	24	0	0
5	River Ayr	14	2	0	32
6	River Dee (Grampian)	91	77	5	5
7	River Deveron	97	155	1	3
8	River Doon	24	9	0	13
9	River Garnock	87	35	0	11
10	River Irvine	87	16	0	0
11	River South Esk (Tayside)	33	41	2	2
12	River Tay	182	112	12	6
13	Stewartry Coastal	40	80	5	8
14	River Ugie*	--	--	--	--

[2] Note that database was composed of 1995 farm observations, but there are 431 observations for which farm type is currently missing.

5.2. Levels of awareness and compliance

As shown in Table 5, most farmers (84%) in the survey self-reported being aware of the Diffuse Pollution GBRs. In addition, most farmers indicated to carry out any soil testing and nutrient budgeting, but a lower proportion have been involved in agri-environmental schemes. The results in Table 6 show that 46% of the farmers included in the dataset comply with the Diffuse Pollution General Binding Rules (GBRs) while 85% comply with the SSAFO regulations. Table 6 also shows the percentage of farmers that are at risk of not complying with some of the GBRs. More than half of the observations (59.8%) are at risk of not complying with GBRs, while 28.9% are at risk of not complying with SSAFO regulations.

Table 5. Awareness of Diffuse Pollution GBRs and involvement in soil testing, nutrient budgeting and/or environmental schemes

Variable	**% farmers (out of 1564)**
Aware of	
GBRs	84.1
Carry out	
Soil Testing	73.4
Nutrient Budgeting	55.3
Agri -Environmental Schemes	37.8

Table 6. Percentage of compliance and farmers at risk of not complying with GBRs and SSAFO regulations

Variable	**% farmers comply (out of 1995)**	**% farmers at risk (out of 1995)**
GBRs	46.2	59.8
SSAFO	84.8	28.9

A chi-square test of independence did not confirm a significant difference in the risk of non-compliance with GBRs between those that are aware of GBRs and those who aren't. However, differences are significant among those carrying out nutrient budgeting. Nutrient budgeting compares nutrients applied to the soil to nutrients taken up by crops, hence, the practice of nutrient budgeting is meant to help farmers make best use of nutrients across the farm; save money and reduce diffuse pollution risks. For that reason, farmers carrying out nutrient budgeting are more likely to reduce the risk of breaking the GBRs.

Amongst farmers not complying with GBRs, the average number of non-compliances is nearly 4. Table 7 below shows the three measures with the highest rates of non-compliance. On the other hand, there was complete compliance with the following GBRs, where they applied: GBR 21b (*Drainage must not result in destabilisation of the banks, or bed of the*

receiving river, burn, ditch, etc.), GBR 23ci (*Pesticide sprayers must not be filled with water taken from any river, burn, etc. unless: a device preventing back siphoning is fitted to the system*) and GBR 24a (*Sheep must be prevented from having access to any river, burn, ditch, etc*.).

Table 7. GBRs with higher levels of non-compliance

Description of GBR*	**Number of non-complying farmers (out of 1995)**	**% non compliance**
19a – Keeping of livestock *Significant erosion or poaching of any land that is within 5m of any river, burn, ditch, etc.*	1132	70.2
19c – Keeping of livestock *Livestock feeders must not be positioned where run-off from around the feeders could enter any river, burn, ditch, etc.*	111	56.8
20ai – Cultivation of Land *Land must not be cultivated for crops if it is: within 2m of any river, burn, ditch, etc.*	579	60.2

*Note: for full GBR details refer to The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended)
http://www.sepa.org.uk/media/34761/car_a_practical_guide.pdf

When looking at the relations between awareness and compliance, statistical analysis did not indicate any significant direct relationship between both variables. However, preliminary regression results suggest that specific practices such as nutrient budgeting and soil testing are positively associated with increased compliance with the GBRs. In addition, there is a positive correlation between awareness and being involved in environmental schemes and/or doing nutrient budgeting and soil testing. Although preliminary, these results seem to indicate that awareness alone does not necessarily have a direct effect on compliance, but when this is mediated by 'hands on' practices, such as nutrient budgeting and soil testing, it may have a positive influence on compliance.

In addition, a chi-square test of independence also confirmed that observed differences in non-compliance across farm type and catchment locations are significant. In this respect, other place-related factors such as environmental conditions and social learning processes might play a key role in explaining uptake of measures and compliance with diffuse pollution regulations.

The lack of relation between awareness and compliance with GBRs may be explained by the different levels of understanding and awareness of GBRs, which are not currently differentiated within the SEPA Geofield survey. Thus, a farmer might have heard about GBRs but does not fully understand them or might not have the capacity to implement the

required action effectively. For example, measures such as those related to spreading manures, applying pesticides and drainage require a high level of understanding and skills that might not be easily acquired or available (Environment Agency, 2014).

6. Discussion

Drawing on theories of behaviour change and empirical data, this study aimed at assessing whether awareness affects farmer behaviour regarding compliance with diffuse pollution regulations in Scotland, and how farmer awareness interacts with other factors that might affect uptake of measures.

The results show that although 86% of the respondents confirmed to be aware of Diffuse Pollution GBRs, awareness is not a significant variable at explaining actual compliance. As mentioned above, this might be explained by farmers' lack of understanding of GBRs or skills and capacity to implement required actions. In addition, as suggested by previous studies (e.g. Environment Agency, 2014; Blackstock, 2007; Kolmuss and Agyeman, 2002), becoming environmentally aware does not automatically result in pro-environmental behaviour; this is contingent on other factors such as income levels of farmers, cost of compliance, cultural and identity factors.

Land property rights may also influence the likelihood to comply, with farmers renting the lands less likely to engage in long-term investments to mitigate diffuse pollution (Vrain et al., 2014; Blackstock, 2007). Farmers also tend to show a lukewarm attitude towards the implementation of less punitive measures such as the voluntary measures than the GBRs and SSAFO regulations where there are sanctions for noncompliance (Vrain et al., 2014). Thus, awareness may only be symbolic but not functional in influencing behaviour where farmers anticipate minor or no sanctions associated with breaking various measures. These factors may explain in part, why there wasn't sufficient evidence supporting the hypothesis that awareness of the GBRs influences farmer behaviour.

Time is a key factor influencing the extent to which a farmer changes his behaviour after receiving the required information. Thus, for example, most farmers complied with the SSAFO regulations which have been in place since 1991, compared to GBRs that have been introduced in 2009. Some farmers may need more time to process and understand environmental management information, others may need relatively longer time frames to adjust to changes due to the technicalities, and cost associated with the uptake of mitigation measures (Environment Agency, 2014; Blackstock, 2007). In the Scottish context, farmers are expected to comply with mitigation measures within a space of one year. However, this time period may be longer (without limit) for the adoption of high cost and structural measures. It is therefore possible that the benefits or influence of awareness on behaviour change may be observed in the longer term.

The results also suggest that practices such as nutrient budgeting and soil testing might reduce the risk of breaching mitigation measures. This may be due to farmers becoming more environmentally minded through a better understanding of the causes of diffuse pollution, mitigation measures and general environmental management knowledge (Vrain et al., 2014; Environment Agency, 2011).

Farming type and catchment are significant factors explaining compliance with GBRs. This highlights the relevance of context in facilitating or constraining farmer behaviour (Blackstock, 2007; Silgo and Massey, 2007; Juntti and Potter, 2002; Hines et al., 1986). In this regard, qualitative work to further understand the factors influencing farmers' behaviour in each context may be relevant. Other relevant variables that may influence farmer behaviour included cultural practices, farmers' level of education and income, farm size, information source, among others (Vrain et al., 2014; Blackstock, 2007; Silgo and Massey, 2007; Juntti and Potter, 2002). However, these factors were unexplored due to lack of data.

7. Conclusions

Results show that 46% of farmers surveyed complied with GBRs and 85% with SSAFO regulations. For all of the GBRs monitored during farm visits, non-compliance was more likely for a subset: keeping livestock (19a, 19c) and land cultivation (20ai). This may be partly explained by the fact that breaches in GBRs such as these are easier to spot than for others. However, it may also provide evidence for a more targeted approach aiming to increase compliance with those specific GBRs. Along this lines, the fact that catchment and farm type are significant variables explaining compliance might also provide support for a more targeted approach.

The study suggests that although awareness has the potential to influence farmer behaviour and possibly making them more environmentally conscious, awareness alone does not always result in improved compliance. The results do prove that awareness is linked to some practices, such as soil testing and nutrient budgeting, which in turn influence compliance. In this regard, encouraging practical 'hands on' approaches may potentially be a useful approach for further improving regulatory compliance to tackle water quality problems.

As argued in the previous section, the fact that some key variables such as awareness are measured in a dichotomous way may overlook some key information (e.g. extent of awareness) which can provide relevant insights to assess the effectiveness of policy interventions such as the Priority Catchment approach. Further research to "un-pack" farmers' awareness, how best to measure this, and its indirect or direct relationships with compliance is required to understand the effectiveness of these policy interventions.

Acknowledgments

This research is funded by the Rural & Environment Science & Analytical Services Division of the Scottish Government, as part of the 2011-2016 and 2016 -2021 Strategic Research Programmes and Commonwealth Scholarship Commission and the University of Leeds. This briefing corresponds to deliverable D2.1 within the project formed by Research Deliverable 1.2.4 Objective 2.1. Authors are grateful to SEPA's personnel for answering to our questions.

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