

RESEARCH ARTICLE

An evaluation of public initiatives to change behaviours that affect water quality

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Abstract

Pollution and environmental depletion are often caused by human behaviours, where if behaviours were modified, environmental pressure could be substantially reduced. Many public programmes aim to influence people to change their unsustainable behaviours but few undertake ex post evaluations of behavioural change programmes. This paper undertakes an evaluation of a 5-year programme to understand whether community engagement activities lead to more sustainable practices. Using a treatment and control experiment, the research investigates whether programme participants are representative of the wider population, whether participation leads to sustainable practices, whether pro-environmental behaviours are sustained over time, and the relative effectiveness of different types of events on individual behaviours. Overall, results suggest that water engagement event participants are more likely to adopt sustainable behaviours, however attendees only represent a small cohort of the wider population, which possibly hinders a wider adoption of good practices. With respect to individual behaviours, different outcomes were detected for different behaviours, which suggests that not all behaviours were equally amenable to change. When comparing the impact of different events, events that are focused on building community ties were more successful than events with simple provision of information. Finally, new pro-environmental behaviours tend to be abandoned after a period of time, therefore re-engagement at regular time intervals is advised.

KEYWORDS

environmental awareness, environmental knowledge, environmental policy, pro-environmental behaviours, water quality

1 | INTRODUCTION

The world is facing several environmental challenges that represent issues of global concern, including climate change and a biodiversity crisis (IPBES, 2019; IPCC, 2014). The quality of freshwater resources and the way in which they are exploited contributes to these environmental challenges (Howells et al., 2013). The sources of environmental pollution are well understood. Within the European Union, the main

significant pressures on surface water bodies are hydromorphological pressures (40%), diffuse sources (38%), particularly from agriculture, atmospheric deposition (38%), point sources (18%) and water abstraction (7%) (EEA, 2018). Preventing water pollution and the remediation of existing contaminated water bodies is a multifaceted and complex policy goal. Most water pressures have an element related to human behaviours, where if behaviours were modified, pollutant loads could be substantially reduced (Cooper et al., 2019; Inman et al., 2018). For

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example, inappropriate discharge of wastes to storm-drains or sewers can ultimately impact on water quality. Changing people's unsustainable behaviours is one of the strategies increasingly advocated to achieve a more efficient use of resources and more sustainable lifestyles (Barr et al., 2011; Maynard et al., 2020). While there are many studies on developing strategies and implementing programmes on behavioural change, most are studies undertaken during the design of behavioural change initiatives (McKenzie-Mohr, 2011). There is a paucity of ex post evaluations of behavioural change programmes. This paper provides an *ex post* analysis of data collected on a 5-year programme of engagements to encourage communities to take responsibility for water quality and catchment management.

Theories and models of behavioural change largely draw from psychology but are also informed by economics and sociology (Michie et al., 2008). In a review excess of 60 behavioural change models, theories and frameworks, Darnton (2008) find that the most common theoretical models underpinning the rationale of the research are the Transtheoretical Model (Prochaska & Velicer, 1997), Social Cognitive Theory (Bandura, 1991) and the Theory of Planned Behaviour (Ajzen, 1991). The Transtheoretical Model segments the target audience and tailors interventions to various sub-groups. Social Cognitive Theory centres around learning from others and using positive and negative reinforcement of behaviour. The Theory of Planned Behaviour posits that behaviours are determined by intention, which are predicted by attitudes, subjective norms and perceived behavioural control.

Also motivated by the psychology, economics and sociology literature there are innumerable interventions to encourage pro-environmental behaviours, many of which are consistent across theoretical models cited above. With innumerable interventions feasible, multiple classifications have been proposed to describe the types of practical interventions to encourage behavioural change (NIEA, 2012; Poortinga & Whitaker, 2018; Rajapaksa et al., 2019; Victoria, 2002; Wallen & Daut, 2018). Wallen and Daut's classification, which is broadly similar to the others, comprises the following categories: (1) education and awareness raising, (2) outreach, relationship building and trust, (3) social influence and (4) behavioural insights and nudges. Where behaviour change is driven from the outside, either via dissemination of technical information or even community discussion groups, success is often limited, as illustrated by Bessette (2020), who finds that an outreach and relationship building (ORB) approach to enable local communities to identify their development needs and specific actions are more successful. The ORB category of interventions is particularly relevant in the context of the European Union's Water Framework Directive (2000/60/EC), among which one of its objectives is to increase the general public's participation in water resource management. The primary ORB interventions include focus groups, training sessions and public meetings but broad participation in ORB events does not imply a strong impact on environmental behaviours (Axon et al., 2018; Doyle & Davies, 2013; Grilli & Curtis, 2021). In a review of some 155 behavioural change interventions, Grilli and Curtis (2021) find that ORB interventions have the highest success rate, above 80%, though quantitative assessments of the interventions are not common. This paucity of assessments represents a deficiency in the literature. Many published behavioural

change studies are either lab-based or random controlled trials, whereas the ORB-type interventions are less amenable to such assessments, as whole communities are involved in the interventions (Aljerf & Choukaife, 2016; Axon et al., 2018; Espinosa & Walker, 2013). Another gap in the literature is quantifying the extent to which behavioural change initiatives are effective over extended periods. Even where there are careful ex ante treatment-control studies, the measured impacts of behavioural interventions are usually limited to a relatively short period after the intervention (Hunter et al., 2015; Luong et al., 2021; Rodda et al., 2017). An open question in the behavioural change literature is whether changed behaviours revert to original state after some period or its intensity decay?

This current research considers behaviour change across an extended timeframe, evaluating the impact of a series of community-level behavioural interventions aimed at improving water quality in Ireland across a 4-year period between 2017 and 2020. Within the context of the EU's Water Framework Directive, the Irish government is developing and implementing policies to protect Ireland's water resources, as outlined in its River Basin Management Plan (RBMP) (DHPLG, 2018). One aspect of that plan is the organisation of community engagement initiatives to increase awareness and build relationships within communities, an action that is led by the Local Authority Water Programme (LAWPRO). This research explores the extent to which initiatives to build community engagement on water quality and river basin management lead to more sustainable practices among (a) community groups and (b) among private individuals. The research questions are: (1) whether the individuals participating in community engagement activities are representative of the wider population or concentrated among narrower population cohorts? (2) whether participation by individuals in community engagement activities leads to participation in community-led initiatives? (3) to what extent does community engagement lead to improved knowledge and changed behaviours among private individuals? (4) which specific engagement activities are most effective in yielding behavioural change among private individuals in the water quality domain? and (5) whether there are time decay effects associated with changed behaviours? This empirical evidence, based on long-term impacts, has relevance for improving the efficacy of existing community engagement initiatives, as well as, for similar behaviour change initiatives elsewhere.

The rest of the manuscript is organised as follows. The methodological section depicts water quality events that are evaluated, questionnaire, data collection and econometric analysis of the data. Section 3 reports findings from the analysis, a discussion of which, including policy implications, is included in Section 4. Section 5 ends with some conclusions.

2 | METHODS

2.1 | Background

LAWPRO (<http://watersandcommunities.ie>) is a government funded national initiative that engages with communities and other stakeholders to achieve the objectives of the RBMP, that is, improve water

quality so that Ireland will achieve 'good' ecological status in water bodies (rivers, lakes, estuaries and coastal waters) by 2027. The focus of this research is part of the work of Communities Team, who support communities and stakeholders in the delivery of local water quality projects and initiatives. LAWPRO partner with other organisations and run initiatives in parallel with third party events (e.g. World Wetlands Day), all of which are the subject of this research. The discussion of water quality and river basin management is a common theme across all these events, though LAWPRO's direct involvement in each event type varies. The following list illustrates the type of community engagement events under consideration.

- Public consultation meetings facilitated by either LAWPRO or others
- Nature-themed public events (e.g. Biodiversity Week)
- Project-related meetings (e.g. rural development, drinking-water source protection)
- Catchment or waterbody meetings
- Community meetings (e.g. Resident's Association)
- Water-related community meetings (e.g. angling groups, water recreation clubs)
- Educational/training events
- Farming group meetings
- Water quality-related conferences

Although these events, particularly the LAWPRO organised events, do not concentrate on individual behavioural change, information received may encourage individuals to adopt behaviours that enhance water quality.

2.2 | Modelling approach

The objective is to investigate the impact of water quality community engagement events on attendee's adoption of pro-environmental behaviours that were discussed during the events. To this end, the treatment and control experiment was undertaken where individuals attending water quality community engagement events comprise the treatment group and individuals who did not attend form the control group. The experiment has several behavioural response variables, some related to community-led initiatives and others that are private actions. The behavioural response variables are recorded as dummy variables equal to 1 if respondents report adopting the specific behaviour and 0 otherwise. In this experimental setting, the estimate of interest is the Average Treatment Effect (ATE), which indicates the impact of the treatment (i.e. participation in a water quality community engagement event) on the response variable (i.e. behaviours) compared to the control group (Zhang et al., 2019). With respect to the objectives of this analysis, ATE measures the difference between the share of respondents in the treatment group that adopt the pro-environmental behaviour compared to the share of respondents in the control group. A positive and statistically significant ATE indicates that the

treatment had an impact on people's adoption of the pro-environmental behaviour.

ATE estimation is conducted using statistical models. Robust statistical inference requires randomly drawn samples (Angrist & Pischke, 2008). In a randomised experiment, robust ATE estimates are attainable with a statistical model that compares average scores between the treatment and control groups, because randomness in data collection ensures that participants are equally likely to be a member of either the treatment or control group. However, this study is not random and sample selection is biased, because participation in water quality community engagement events is on a voluntary basis, which means that the allocation of participants to the treatment group is not by chance. For example, sources of selection bias are personal tastes and interests, proximity to the event venue, job type, personal commitments and exposure to event advertising. In this non-random experiment the probability of being treated is endogenous because it depends on personal characteristics, and a simple comparison of average values between treated and control groups would result in biased ATE estimates. The non-random nature of the experiment and selection bias concerns are addressed using the propensity score matching (PSM) method (Rosenbaum & Rubin, 1983), which is one of the most popular approaches to derive unbiased estimates in the presence of selection in cross-sectional data. An advantage of the PSM approach for impact evaluation across comparable groups is that, unlike regression techniques, it does not require a specific functional form (Redmond & McGuinness, 2019). The core of a PSM investigation is to identify a sub-sample of the control group with characteristics very similar to the treatment group so that comparisons are undertaken between two similar groups (Black & Smith, 2004). The identification of a control sub-sample and estimation of the effect of treatment, T_i , using a PSM procedure involves the following steps (Cameron & Trivedi, 2005):

1. Run a binary regression model (e.g. logit) using T_i as a response variable and a set of covariates that affect the probability of being treated as predictors;
2. Calculate probabilities of being treated for both control and treatment groups;
3. Use the calculated probabilities to match each treatment observation with a control observation, using a matching procedure (e.g. nearest neighbour, Mahalanobis distance, calliper matching, exact matching);
4. Calculate the ATE for all response variables (i.e. indicators of behaviour change) on the new sample of matched (treatment and control) observations. The response variables, which are described in Section 2.5, include behaviours related to community-led initiatives and private actions.

Logit regressions are used to estimate treatment probabilities for each treatment (i.e. Steps 1–2). The logit model is an econometric specification for binary outcomes, where the probability of being treated is described by the following probability distribution function (Greene, 2003):



$$\Pr[T_i = 1|X] = \frac{\exp(X_n^T \beta)}{\exp(X_n^T \beta) + 1} \quad (1)$$

where T_i is the treatment, X_n is a matrix of socio-demographic characteristics of the individual n , β represents a vector of coefficients to estimate. The nearest neighbour approach is used as the matching procedure in Step 3 for this application (Austin, 2014). ATE estimation and significance testing in Step 4 is based on testing equality of means of treatment and matched control group for specified voluntary water quality activities. Means are proportions of the treatment and matched control groups that engage in voluntary water quality activities. The t -test on the ATE being equal to zero uses the Abadie-Imbens standard error (Abadie & Imbens, 2006). The statistical analyses use the R software package; logit models for treatment probabilities are estimated using the 'glm' function from the base installation, while the ATE assessment is undertaken using the 'Match' function from the 'Matching' package (Sekhon, 2011).

2.3 | Questionnaire and data

The data for this study originated from two separate online surveys, one for the treatment group and one for the control group. Data collection capturing behavioural responses did not occur contemporaneously with LAWPRO's activities between 2017 and 2017, rather data were collected retrospectively in 2020. The treatment group survey was administered to registered participants of LAWPRO water events. LAWPRO issued an email invitation to participate in the survey with data collection occurring during June 2020. A follow-up reminder email was sent 1 week after the initial email. In total, 436 responses were received. As some respondents failed to complete key questions relevant for the analysis here, the number of observations reduced to 385.

The control group survey was also an online survey but with a sample drawn from the panel book of a professional survey company. The company's panel comprises adults resident in Ireland but the sample drawn for this study was not designed to be representative of the population. Instead the objective was to acquire a sufficiently large control group sample to enable adequate PSM attendee matching. The planned sample size for the control group was intended to achieve an approximate 10:1 ratio between treatment and control group samples, which is considered a sufficient ratio to find a good match for each treatment group observation (Austin, 2010). The control group survey was administered in July 2020 and the total number of observations is 3544.

The same questionnaire was administered to the two samples. The questionnaire comprised 34 questions organised across thematic sections, which was drafted in consultation with LAWPRO to understand the types of events that were organised, the environmental behaviours promoted, and the information delivered to participants. The first section included warm-up questions to introduce the survey topic, understand perceptions of the water quality status of Irish waters and gather information on number and types of event

attended. The second section comprised questions on the most recent water quality event attended, enabling respondents to recall details with greater accuracy. In this instance information about the type of event, when the event took place, the reason for attending and their level of satisfaction was collected. The third and fourth sections contained questions about knowledge of water issues and on behaviours that respondents undertake within their home, outside their home (i.e. in the garden) and about purchasing behaviours. The final section gathered socio-demographic information.

Descriptive statistics of the samples are reported in Table 1. The control group survey was not stratified by socio-demographic quotas and, when compared to census statistics, males were under-sampled by some 8%, while younger respondents were over-represented. The larger share of young respondents is common in web surveys, because older people are less likely to own a computer or an internet connection (Bethlehem, 2010) and in this instance be members of the survey company's online panel. The treatment group comprises a larger share of males and older people. The study was conducted in a quasi-experimental setting with the treatment group affected by selection bias, therefore equal representation of some population cohorts was not anticipated. Comparable data from the 2016 census of population are also reported for information purposes.

2.4 | Treatments

Several categories of treatment groups, T_i , are generated from the sample of respondents who attended community engagement events related to water quality based on number, type and year of most recent event attended. This categorisation enables investigation of whether the level of behavioural change is associated with type, frequency and duration of community engagement activities. Seven treatments are considered, which are described in the following paragraphs.

T1: Attendance at a minimum of one community engagement event This is the treatment that includes all respondents of the treatment survey, that is, all the people who attended at least one event ($N = 385$).

T2: Attendance at a minimum of four community engagement events This treatment is included as an approximation for respondents that were exposed to a greater depth of information about water quality. The survey did not elicit information on the number of events attended each year due to concerns about the ability of respondents to recall such precise information over a 4-year timeframe. So the treatment is exceeding a threshold intensity of engagement equivalent to an average of 1 event per year between 2017 and 2020.

T3–T5: Attendance only at specific event types It would be preferable to undertake separate analysis for each of the nine event types included in the survey but the number of respondents who attended some of these events is too low to achieve meaningful results. Figure 1, which reports the number of attendees within the treatment group by event type, shows that within the dataset only three event types were attended by more than 100 respondents. To avoid biases

TABLE 1 Descriptive statistics: treatment and control groups

Variable	Treatment group (N = 385) Frequency	Control group (N = 3544) Frequency	Census ^a Frequency
Males	0.62 (0.49)	0.41 (0.49)	0.49
Age			
18–24	0.01 (0.10)	0.20 (0.40)	0.15
25–34	0.04 (0.19)	0.25 (0.44)	0.37
35–44	0.15 (0.35)	0.23 (0.42)	
45–65	0.59 (0.49)	0.25 (0.43)	0.30
66+	0.21 (0.41)	0.06 (0.24)	0.17
Education			
Secondary school or lower	0.17 (0.37)	0.30 (0.46)	0.48
Undergraduate/technical	0.38 (0.49)	0.45 (0.50)	0.41
Postgraduate	0.45 (0.50)	0.25 (0.43)	0.11
Net Income per month			
<e1500	0.11 (0.31)	0.21 (0.41)	
e1501–2000	0.16 (0.37)	0.22 (0.41)	
e2001–4000	0.46 (0.50)	0.39 (0.49)	
e4001–6000	0.19 (0.39)	0.14 (0.35)	
e6000+	0.08 (0.26)	0.05 (0.21)	

Note: Standard deviations in parenthesis.

^aReported census of population age cohorts are ages 15–24, 25–44, 45–64, and 65+.

due to low sample size some similar event types were combined plus a minimum sample size of 100 was set. Specifically, these events are:

- T3: Public meetings facilitated by LAWPRO (N = 219).
- T4: Nature *themed* public events (N = 145), which comprises public events that included a water quality or catchment management-related theme. Examples include events related to World Wetlands Day, Heritage Week, Biodiversity Week, as well as local events that included a catchment management-related exhibit.
- T5: Community group meetings (N = 180) which comprise local non-government organisation (NGO) groups related to community development (e.g. Resident's Association) or water focused activities (e.g. angling, coastal group)
- T6: If the most recent event attended was in 2017 or 2018 The time elapsed since the most recent event attended may have an impact on individuals' behaviours. Recent attendance at a community engagement event may encourage pro-environmental behaviours in the short run but behaviours may revert after some time has elapsed.
- T7: If the most recent event attended was in 2019 or 2020 results of the analysis of this treatment will be interpreted with those from T6 to examine short and long run behavioural change effects associated with attendance at water quality community engagement events. The objective is to learn if the behavioural change is sustained over time.

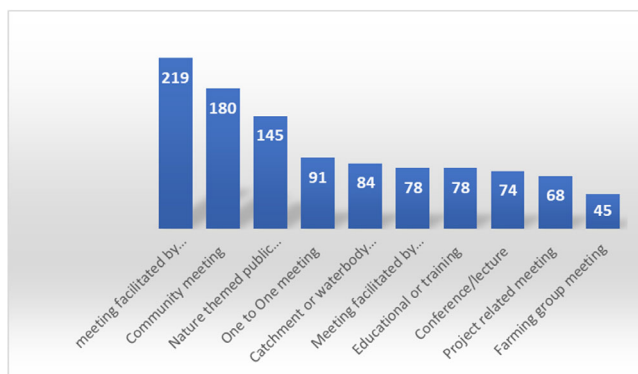


FIGURE 1 Number of attendees for each type of water quality event

2.5 | Response variables: Adoption of pro-environmental behaviours

Response variables fall into two categories: those related to community-led initiatives, and those related to private actions.

2.5.1 | Community-led initiatives

As a result of the community engagement events, whether facilitated by LAWPRO or other organisations, participants may have been sufficiently motivated to engage in community-led initiatives to improve or protect water quality in their locality. Three types of initiative are considered where the respondent:

C1: Organised a local water-related event or project;

C2: Joined a local group that cares for water quality;

C3: Participated in a citizen science initiative (i.e. an initiative that encourages citizen participation in scientific research, e.g. water nitrogen monitoring, fish species data recording).

For the PSM analysis, the difference in shares between the treatment and control groups undertaking the action is examined in each case. Due to a survey design coding error survey respondents were only able to indicate if they had undertaken one rather than any of the activities, C1–C3. While this limits the nature of the data collected, it is unlikely to substantially impact on the empirical results on whether engagement events have an impact on people participating in community-led events.

2.5.2 | Private actions

Participation in community engagement events may also impact on individuals' adoption of sustainable behaviours. In the case of LAWPRO, influencing individual private behaviours is not a specific objective but the theme of several treatment types is the adoption of more sustainable behaviours, including resource use, waste management and water protection. A broad range of sustainability issues were potentially mentioned in the engagement events and are

classified here into six groups: in-home behaviours, outside-home behaviours, purchasing behaviours, knowledge of water management schemes, reporting environmental damage and workplace behaviours.

R1: In-home behaviours: In-home behaviours are actions that people can take inside their home that could potentially affect water quality. The behaviours considered are R1.1: Conserve water (e.g. owning dual flush toilet or a cistern bag); R1.2: Avoid flushing plastic, wipes and other polluting items down the toilet; R1.3: Use brown bins for food waste; R1.4: Avoid the use in-sink food macerators. Answers were coded as 1 if the respondent adopted the behaviour regularly and 0 if not adopted. Individual behaviours were also aggregated in a response variable, R1.C, capturing the total number of behaviours pursued by respondents, which ranged between 0 for respondents who did not adopt any of the behaviours and 4 for respondents who adopted all in-home behaviours. For the PSM analysis, the difference in shares between the treatment and control groups undertaking the behaviour is examined in the case of R1.1–R1.4, while the difference in mean counts is considered for R1.C.

R2: Outside-home behaviours: Outside-home behaviours are related to the management of garden and private outdoor spaces. The questionnaire considered five pro-environmental behaviours, R2.1: Use a water butt to harvest rainwater for garden use; R2.2: Avoid the use of chemical products; R2.3: Grow vegetables organically; R2.4: Have a private well tested annually; R2.5: Regular maintenance of septic tank. Coding and analysis of the individual and collective behaviours is similar to those for in-home behaviours. The aggregated response variable for outside-home behaviours is labelled R2.C.

R3: Purchasing behaviours: Purchasing behaviours relate to the attention that people give as consumers to the products purchased. With respect to water quality impact, three behaviours were identified: R3.1: Reduce the purchase of clothes; R3.2: Avoid single use plastic; and R3.3: Purchase environmentally friendly cleaning products. The aggregated purchasing behaviours variable was labelled R3.C.

R4: Knowledge of water management schemes: This analysis captured respondents' awareness of water management in Ireland based on one survey question and a follow-up. The first question asked respondents to indicate the level at which Irish waters are managed with four candidate answers (river level, catchment level, regional level and national level), R4.1. Respondents who selected the correct answer (i.e. catchment level) received a follow up question, in which they were asked to indicate the approximate number of catchment management units in Ireland's RBMP, R4.2. The PSM analysis for these indicators is the share of respondents who reported the correct answer.

R5: Attitudes towards environmental damage reporting Respondents were asked to indicate if they witnessed a water pollution incident in the past, which was used to assess attitudes towards reporting environmental pollution to the relevant authorities. The question was designed as a 'yes-no' question with a follow-up based on the answer. Where respondents witnessed a water pollution incident, the follow-up question asked to indicate whether they reported the incident to one of a number of relevant institutions or not. The analysis for this indicator, R5.1, is the share of respondents who stated they reported the pollution incident.

R6: Behaviours in the workplace: The questionnaire included two questions on behaviours in the workplace, one for farmers and one for business owners and other workers. These questions were preceded by a screening question that asked the type of occupation and automatically diverted respondents to the relevant questions. Four relevant behaviours were identified for farmers, R6.1: Adoption of a nutrient management plan for a more targeted use of slurry and fertiliser; R6.2: Adoption of new land management actions for nutrient retention; R6.3: Implementation of new farmyard practices to control soiled waters; and R6.4: Use of Protected Urea instead of Urea or CAN (calcium ammonium nitrate). A dedicated question for farmers was included because they represent an important class of stakeholders in water management with a potential high impact on water quality when best practices are not pursued. Unfortunately, farmers' recruitment in the survey of attendees was limited, therefore PSM analyses were conducted on relatively small sample sizes. Results on farmers' behaviours are displayed due to the importance of this group in water management but results should be interpreted with caution.

With respect to business owners or other workers, six behaviours are considered, R6.5: Keep informed of best environmental practice; R6.6: Awareness of workplace water usage and waste water treatment; R6.7: Audited water usage and engagement in a water conservation programme; R6.8: Understanding of environmental regulations and best practice to comply with their work/business, R6.9: Active promotion of sustainable practices in the organisation/workplace (such as water conservation, care with chemicals, waste management, reduction of single use plastic); and R6.10: Awareness of drainage and the need to separate clean and soiled/waste waters.

3 | RESULTS

3.1 | Binary models for attendance probabilities

Across the treatment groups, T1–T7, the logit model estimates are generally internally consistent with each other in terms of the association between socio-demographic variables and the likelihood of treatment. Only in a small number of cases do the sign of the estimated coefficients change between models and in those instances the coefficient estimates are not significantly different from zero. This indicates that the relevant socio-demographic variable is not associated with the likelihood of treatment (i.e. attendance at requisite community engagement events). The estimated logit coefficients are not easily interpreted and instead odds ratios are reported in Table 2. Odds ratios greater than one indicate higher likelihood of being in the treatment group, while odds ratios less than one indicate the opposite. With respect to respondents' age all reported odds ratios are less than 1, which indicates that compared to the reference category of people aged above 65 years, all cohorts are less likely to be in the treatment group. For example, people aged 35–45 are 0.16 times as likely to be in the T1 treatment group compared to those aged 66 and older. The estimated odds ratio of those aged 45–65 is not significantly different than one, which indicates that this group has a similar likelihood of

being in the treatment group as the reference category. Respondents in the two highest age cohorts are equally likely to attend the water quality community engagement events, whereas the younger age cohorts have a lower likelihood of being in the treatment group.

The likelihood of being in the treatment group, that is, attendance at community engagement events, is correlated with gender and varies across treatments. Broadly, men are more likely to attend water quality community engagement events and for some treatments, twice as likely as women. The odds ratios for household size are not significantly different than one, which suggests that there is no association with likelihood of being in the treatment group.

Respondents with a post-graduate level education are between 2 and 6 times more likely to attend community engagement events across the T1–T7 treatment groups compared to those with secondary education. The respondent attribute associated with the highest likelihood of being in any of the seven treatment groups is being a representative of an NGO. The variable indicates that the respondent was representing a voluntary organisation concerned with angling, water, local development or the environment. The likelihood of being in the treatment group is between 8 and 17 times higher for NGO representatives compared to non-representatives. Three variables were included in the logit models to capture economic or social status: occupation, income and financial comfort. For occupation, managerial positions are the reference category and the only occupation category with a significantly different likelihood of being in any of the treatment groups is non-manual positions. With respect to income there is no association between income level and treatment group.

The financial comfort variable is a respondent assessment of whether in terms of their household income they are 'struggling to make ends meet' or are 'living comfortably'. Those in the latter category are 2–4 times more likely to be in a treatment group.

3.2 | Pro-environmental behaviours: Matching results

3.2.1 | Community-led events

Table 3 presents matching results for engagement in community-led initiatives related to water protection. The ATE estimates, which indicate the difference in probability of engaging in the behaviour, are all positive and statistically significant across treatments. This indicates that respondents in the treatment group are more likely to participate in community-led events compared to the control group. With respect to T1, which comprises all attendees of at least one community engagement event, respondents were 20.7 percentage points more likely to organise water-related events, 35.4 percentage points more likely to be part of a group on water quality and 12.9 percentage points more likely to take part in a citizen science initiative. The magnitude of the ATE estimates is similar across treatments, which indicates that success in convincing people to get involved with community groups focusing on water protection does not vary with intensity or type of engagement event.

**TABLE 2** Logit models for the estimation of treatment probabilities in each treatment

Dependent variable treatment group	T1	T2	T3	T4	T5	T6	T7
<i>Age (ref: 66+)</i>							
18–24	.007*** (.004)	.011*** (.008)	.008*** (.006)	.013*** (.011)	.014*** (.009)	0*** (0)	.012*** (.007)
25–34	.022*** (.008)	.029*** (.014)	.035*** (.015)	.044*** (.022)	.031*** (.015)	0*** (0)	.036*** (.014)
35–44	.163*** (.042)	.229*** (.077)	.192*** (.059)	.314*** (.117)	.158*** (.057)	.049*** (.023)	.21*** (.059)
45–65	.808 (.166)	1.198 (.334)	.755 (.186)	.901 (.291)	.834 (.237)	.626* (.191)	.921 (.215)
Male (ref: female)	1.647*** (.245)	2.175*** (.428)	2.073*** (.392)	1.037 (.226)	1.467 (.304)	1.359 (.341)	1.852*** (.305)
No. of household members	1.057 (.061)	1.027 (.077)	1.004 (.07)	1.003 (.087)	1.044 (.082)	1.02 (.1)	1.08 (.068)
<i>Education (ref: Secondary)</i>							
Undergraduate degree	1.492 (.303)	1.603 (.439)	1.381 (.348)	3.511* (1.359)	1.904 (.571)	1.2 (.379)	1.499 (.346)
Postgraduate degree	3.36*** (.726)	3.811** (1.094)	2.892** (.772)	6.554** (2.635)	4.468** (1.403)	2.542* (.849)	3.394*** (.828)
NGO representative (ref: otherwise)	11.056*** (1.78)	17.796*** (3.524)	8.776*** (1.632)	11.977*** (2.623)	15.927*** (3.249)	14.527*** (3.835)	11.427*** (1.988)
Public Employee (ref: otherwise)	2.234*** (.436)	2.257** (.546)	2.418** (.556)	1.96* (.531)	1.793 (.482)	2.861* (.995)	1.933** (.412)
<i>Financial Comfort (ref: struggling)</i>							
Living Comfortably	2.442*** (.425)	1.941** (.435)	2.581*** (.575)	1.97* (.522)	1.923** (.458)	4.332** (1.356)	2.173*** (.415)
<i>Occupation (ref: Managerial)</i>							
Manual	.742 (.184)	.46*** (.164)	.73 (.233)	.353*** (.161)	.548** (.191)	1.433 (.57)	.638** (.179)
Non-manual	.24*** (.088)	.354*** (.155)	.327*** (.143)	.241*** (.132)	.177*** (.097)	.277*** (.177)	.263*** (.105)
Other	.927 (.258)	.965 (.34)	.773 (.294)	.746 (.307)	.729 (.274)	1.018 (.461)	.908 (.281)
Professional	.867 (.146)	.791 (.169)	1.007 (.206)	.68** (.163)	.549*** (.126)	1.271 (.374)	.855 (.156)
Income (ref: Less than e1500/month)	1.409 (.361)	1.28 (.449)	1.677 (.58)	1.079 (.437)	1.018 (.359)	.96 (.394)	1.672 (.49)
e1501-2000/month	1.388 (.329)	1.582 (.505)	1.684 (.551)	1.309 (.482)	1.123 (.36)	1.112 (.402)	1.456 (.402)
e2001-4000/month	1.214 (.351)	1.322 (.502)	1.749 (.658)	1.373 (.592)	.937 (.365)	.654 (.311)	1.449 (.474)
e4001-6000/month	1.966 (.718)	2.846 (1.326)	2.529 (1.181)	2.517 (1.349)	.898 (.477)	1.554 (.942)	2.119 (.875)
e6000+/month	.054*** (.036)	.025*** (.02)	.012*** (.012)	.028*** (.026)	.047*** (.038)	.02*** (.022)	.029*** (.022)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County dummies	3929	3767	3784	3717	3748	3665	3838
Observations							

TABLE 2 (Continued)

Dependent variable treatment group	T1	T2	T3	T4	T5	T6	T7
Log Likelihood	-715	-456	-505	-362	-412	-285	-606
Akaike information criterion	1521	1001	1099	814	914	659	1303

Note: Logit estimates reported as odds ratios & significance tests from 1.

* $p < .1$, ** $p < .05$, *** $p < .01$.

TABLE 3 Engagement in community-led initiatives to improve or protect water quality

	C1 Organised water event	C2 Member of water protection group	C3 Joined citizen science initiative
T1			
ATE	.207***	.354***	.129***
SE	(.036)	(.042)	(.028)
Matched Obs	385	385	385
T2			
ATE	.219***	.353***	.088**
SE	(.058)	(.056)	(.043)
Matched Obs	223	223	223
T3			
ATE	.151***	.446***	.117***
SE	(.039)	(.045)	(.032)
Matched Obs	219	219	219
T4			
ATE	.285***	.169**	.173***
SE	(.063)	(.066)	(.040)
Matched Obs	145	145	145
T5			
ATE	.228***	.313***	.107***
SE	(.052)	(.055)	(.039)
Matched Obs	180	180	180
T6			
ATE	.196***	.292***	.156***
SE	(.054)	(.072)	(.045)
Matched Obs	121	121	121
T7			
ATE	.221***	.419***	.127***
SE	(.042)	(.044)	(.032)
Matched Obs	294	294	294

* $p < .1$, ** $p < .05$, *** $p < .01$.

3.2.2 | Private actions

Results of private action PSM analyses are reported across three tables. Results related to individual private response variables, excluding those related to the workplace, are reported in Table 4, where information on the ATE, estimated standard errors and number of

matched observations between the treatment and control groups is reported for each of the seven treatments. The columns relate to single behaviours or response variables (e.g. R1.1 or R1.2) and the ATE value indicates the difference in probability of engaging in the behaviour (e.g. conserving water, or avoiding flushing plastic items down toilet) between the treatment and control groups. For example, for R1.1, the ATE value of 0.108 for the T1 treatment indicates that the treatment group is 10.8 percentage points more likely to engage in water conservation compared to the control group and the estimate has statistical significance at 5% level. In the case of R1.2, the ATE estimate is not significant across any of the treatment groups indicating there is no observable difference in behaviour between those that attended community engagement events relative to those that did not. Treatments T1 and T2 refer to the attendance at a minimum of one and a minimum of four events, respectively. One would anticipate that the ATE for T2 is not less than the ATE for T1, which is the case in some but not all instances. One case where there is a notable difference is knowledge of water catchment management, R4.1, where the ATE is 0.497 versus 0.315. Respondents that attended just one community engagement event, T1, are 31.5 percentage points more likely to know the level at which Irish waters are managed compared to the control group. In the case of T2, where respondents have attended a minimum of four community engagement events, the comparable figure is 49.7 percentage points. Treatments T3–T5 are differentiated by type of water quality community event; those facilitated by LAWPRO; nature-themed public events; and community group meetings. Across the response indicators, R1.1–R5.1, the different event types appear to influence different behaviours. For example, respondents that have attended events facilitated by LAWPRO are less likely to use in-sink macerators, whereas those that attend community group meetings are more likely to segregate organic waste streams (i.e. brown bin) relative to the control group.

Table 5 presents the PSM results for response variables that capture the aggregation of individual behaviours (labelled as R_c). The ATE is the difference in mean counts of behaviours in the treatment versus the control group. In the case of treatment T1 and the count of in-home behaviours, R1.C (e.g. conserving water, not flushing wipes, etc.), the estimated ATE is 0.265, which indicates that the treatment group, on average, undertake 0.26 additional in-home behaviours than the control group. For outside-home behaviours, R2.C, there is a similar ATE value at 0.247, and similarly for purchasing behaviours, R3.C, at 0.251. The final column calculates the ATE across all the individual behaviours reported in Table 4. For treatment T1, the mean additional number of behaviours undertaken compared to the control group is 0.76. When the treatment is T2, which is a minimum of four water quality community engagement events, the ATE is 1.037, roughly one



TABLE 4 PSM results for the different outcomes across treatments

	R1.1 Conserve water	R1.2 No flush wipes	R1.3 Brown bin use	R1.4 Avoid sink macerator	R2.1 Collect rain water	R2.2 Use of chemicals	R2.3 Grow vegetables organically	R2.4 Septic tank maintenance	R2.5 Privat well testing	R3.1 Purchase less clothes	R3.2 Avoid single-use plastic	R3.3 Env. friendly products	R4.1 Knowledge of water management	R4.2 Number of catchments	R5.1 Incident reporting
T1															
ATE	.108**	.022	.042	.093***	.043	-.016	.045	.054	.12***	.121**	.073*	.057	.315***	.143*	.034
SE	(.04)	(.02)	(.05)	(.03)	(.05)	(.03)	(.05)	(.04)	(.03)	(.05)	(.04)	(.05)	(.05)	(.08)	(.07)
Matched Obs	385	385	385	385	385	385	385	385	385	385	385	385	382	225	227
T2															
ATE	.124**	.051	.088	.079**	.077	.045	.067	.089	.108**	.078	.111*	.121*	.497***	.159**	.104
SE	(.06)	(.03)	(.06)	(.04)	(.07)	(.04)	(.07)	(.07)	(.04)	(.07)	(.06)	(.07)	(.06)	(.08)	(.07)
Matched Obs	223	223	223	223	223	223	223	223	223	223	223	223	221	147	152
T3															
ATE	.107**	.026	-.01	.075***	-.004	-.04	-.022	.034	.13***	.148***	.053	.042	.399***	.188**	.022
SE	(.04)	(.02)	(.05)	(.03)	(.05)	(.03)	(.05)	(.05)	(.04)	(.05)	(.04)	(.05)	(.05)	(.08)	(.07)
Matched Obs	219	219	219	219	219	219	219	219	219	219	219	219	217	145	146
T4															
ATE	.134**	.019	.121*	.053	.165**	.047	.104	.082	.028	.103	.118**	.134*	.318***	.181**	-.04
SE	(.06)	(.03)	(.07)	(.04)	(.07)	(.04)	(.07)	(.07)	(.04)	(.07)	(.06)	(.07)	(.07)	(.08)	(.07)
Matched Obs	145	145	145	145	145	145	145	145	145	145	145	145	145	103	108
T5															
ATE	.084*	-.012	.157***	.017	.019	.007	.094	.01	.073	.159***	.124**	.144**	.352***	.074	.071
SE	(.05)	(.03)	(.06)	(.03)	(.06)	(.03)	(.06)	(.06)	(.05)	(.06)	(.05)	(.06)	(.07)	(.09)	(.09)
Matched Obs	180	180	180	180	180	180	180	180	180	180	180	180	180	117	133
T6															
TE	.079	.029	.047	.094**	.096	.052	-.021	-.063	.1	.074	-.014	-.034	.339***	.174	-.05
S	(.08)	(.03)	(.08)	(.04)	(.08)	(.05)	(.08)	(.08)	(.06)	(.09)	(.06)	(.08)	(.08)	(.12)	(.12)
Matched Obs	121	121	121	121	121	121	121	121	121	121	121	121	119	60	67
T7															
ATE	.102**	.002	.109*	.048*	.012	-.003	.062	.076	.134***	.156***	.021	.184***	.382***	.102	.082
SE	(.04)	(.02)	(.06)	(.03)	(.06)	(.04)	(.06)	(.05)	(.04)	(.05)	(.05)	(.05)	(.05)	(.08)	(.08)
Matched Obs	294	294	294	294	294	294	294	294	294	294	294	294	291	181	178

* $p < .1$, ** $p < .05$, *** $p < .01$.

TABLE 5 PSM results for the count of behaviours

	R1.C Home behaviours	R2.C Outside behaviours	R3.C Purchasing behaviours	R1.C + R2. C + R3.C All behaviours
T1				
ATE	.265***	.247**	.251***	.762***
SE	(.07)	(.10)	(.09)	(.17)
Matched obs	385	385	385	385
T2				
ATE	.342***	.386***	.309***	1.037***
SE	(.10)	(.15)	(.12)	(.27)
Matched obs	223	223	223	223
T3				
ATE	.194***	.099	.242**	.535***
SE	(.07)	(.11)	(.10)	(.18)
Matched obs	219	219	219	219
T4				
ATE	.327***	.425***	.355***	1.107***
SE	(.11)	(.14)	(.12)	(.27)
Matched obs	145	145	145	145
T5				
ATE	.246***	.202	.427***	.875***
SE	(.08)	(.13)	(.11)	(.23)
Matched obs	180	180	180	180
T6				
ATE	.249**	.164	.026	.439
SE	(.11)	(.17)	(.13)	(.28)
Matched obs	121	121	121	121
T7				
ATE	.261***	.281**	.36***	.902***
SE	(.08)	(.12)	(.10)	(.20)
Matched obs	294	294	294	294

* $p < .1$. ** $p < .05$, *** $p < .01$.

behaviour more than people in the control group. For treatment T3, the mean number of additional behaviours relative to the control group is 0.535, whereas for treatments T4 and T5, the ATE values are higher at 1.1 and 0.87, respectively. The mean number of changed behaviours among participants at LAWPRO facilitated events is half that of participants at nature-themed events. However, the standard errors for the estimates are relatively large resulting in the 95% confidence intervals for the point estimates overlapping to a substantial degree.

Treatments T6 and T7 are differentiated by the time-frame since attendance at the most recent event. For T6, it relates to 2017–2018 and for T7, it is 2019–2020. The ATE for the mean number of additional behaviours relative to the control under T6 is 0.439 but the estimate is not statistically significant.¹ Under T7, the ATE for the mean number of additional behaviours relative to the control is 0.902

and statistically significant. The implication is that there is a time decay effect associated with community engagement events that seek¹ to change behaviours for the improvement of water quality.

PSM results for behaviours in the workplace are reported in Table 6. Farming-related behaviours are displayed on the left and relate to just 63 matched observations, so the sample is relatively small and any conclusions are subject to greater uncertainty. Nonetheless results on farmers' behaviours are reported due to the importance of agriculture for water quality. Farmers who attended water quality engagement events (T1 and T2) are more likely to adopt new farmyard practices to control soiled water, R6.3, compared to a control group of farmers that did not attend water quality events. The greatest impact on farmer behaviours appears to arise where the engagement events are facilitated by LAWPRO, that is, T3. Farmers engaged in such a treatment are 43 percentage points more likely to implement good farmyard practices for control of soiled water (R6.3); are 24 percentage points more likely to adopt a nutrient management plan for more targeted use of slurry and fertiliser (R6.1); and 18 percentage points more likely to adopt new land management actions for nutrient retention (R6.2) compared to a control group of farmers that did not attend water quality events. Where farmers attended nature-themed events (T4) or community group meetings (T5), there is no evidence of any additional behaviours compared to the control group, though these results are based on very small samples. Curiously, the findings for the time-decay effects are reversed compared to the wider population. Under T6, estimated ATEs are positive and statistically significant in two instances (i.e., R6.1 and R6.3) but are not statistically significant in any instance under T7. There is no intuition on why this is the case but with the small sample sizes it is unwise to draw any firm conclusions.

Table 6 also reports ATE estimates for pro-environmental behaviours among other business types, including business owners and workers. All seven treatments (T1–T7) are associated with a statistically significant and positive impact for 5 of 6 of the considered behaviours, with the exception related to auditing water usage and implementation of a water conservation programme (R6.7). With respect to the magnitude of treatment impact, differences are negligible between T1 and T2, and are similarly negligible between T3, T4, and T5. On time-decay effects, ATE values for event attendees during 2019–2020 (T7) are generally higher than for respondents where their most recent attended event was in 2017 or 2018 (T6), though the differences in ATE values between T6 and T7 are relatively small with overlapping confidence intervals.

4 | DISCUSSION

4.1 | Participation in engagement events

While many people attend LAWPRO's community engagement events, the composition of participants is not representative of the wider adult population. From the descriptive statistics of the treatment group in Table 1, attendees are disproportionately older and

**TABLE 6** Impact of event attendance on behaviours at workplace

Behaviours of farmers		Behaviours of workers and business owners								
R6.1	R6.2	R6.3	R6.4	R6.5	R6.6	R6.7	R6.8	R6.9	R6.10	
Have nutrient plan	Nutrient retention	Good farmyard practices	Use protected urea	Know best practices	Aware water usage	Audit water usage	Understand env. regulation	Promote best practices	Aware of drainage	
T1										
ATE	-.127	.238	.46*	.222	.549***	.352***	.028	.433***	.355***	.466***
SE	(.29)	(.25)	(.25)	(.23)	(.06)	(.07)	(.05)	(.06)	(.07)	(.06)
Matched obs.	63	63	63	63	180	180	180	180	180	180
T2										
ATE	.174*	.026	.277***	-.029	.586***	.348***	.077	.463***	.443***	.489***
SE	(.10)	(.09)	(.10)	(.07)	(.07)	(.08)	(.05)	(.07)	(.08)	(.07)
Matched obs.	29	29	29	29	111	111	111	111	111	111
T3										
ATE	.246***	.181**	.431***	.104	.643***	.351***	.014	.389***	.394***	.418***
SE	(.09)	(.09)	(.09)	(.08)	(.06)	(.07)	(.05)	(.08)	(.07)	(.07)
Matched obs.	40	40	40	40	105	105	105	105	105	105
T4										
ATE	.148	.102	.093	-.009	.523***	.464***	.101**	.436***	.378***	.456***
SE	(.15)	(.14)	(.14)	(.11)	(.07)	(.07)	(.05)	(.08)	(.08)	(.08)
Matched obs.	12	12	12	12	84	84	84	84	84	84
T5										
ATE	.07	-.046	-.046	.019	.622***	.471***	-.089	.42***	.471***	.463***
SE	(.13)	(.11)	(.11)	(.10)	(.07)	(.08)	(.06)	(.08)	(.07)	(.06)
Matched obs.	16	16	16	16	90	90	90	90	90	90
T6										
ATE	.303***	.07	.318***	.119	.382***	.416***	0	.292***	.216**	.271**
SE	(.11)	(.11)	(.12)	(.11)	(.11)	(.08)	(.08)	(.10)	(.10)	(.12)
Matched obs.	21	21	21	21	52	52	52	52	52	52
T7										
ATE	-.062	.208	.479	.25	.649***	.472***	-.063	.442***	.34***	.485***
SE	(.28)	(.31)	(.31)	(.22)	(.06)	(.07)	(.06)	(.06)	(.08)	(.07)
Matched obs.	48	48	48	48	138	138	138	138	138	138

* $p < .1$. ** $p < .05$, *** $p < .01$.

more highly educated, with 80% aged 45 and above compared to 47% in the wider population and 45% with post-graduate degrees compared to just 11% in the wider population. These findings are also reflected in the logit probability results reported in Table 2, where three additional key factors were identified as being associated with attending LAWPRO events. First, across all socio-demographic variables the highest odds ratio is associated with being a representative of an NGO. The other variables with high odds ratios are public employees and those that have sufficient income to live comfortably. These findings suggest that, at present, water quality community engagement events are attracting a specific cohort of society and that the message on ways to protect and improve water quality in rivers lakes, groundwater, estuaries and coastal waters is not necessarily reaching all sections of the community. The high odds ratio for NGOs

can be viewed as a success because the activation of communities via local NGOs to take responsibility for water quality and catchment management is part of LAWPRO's strategy to engage with the wider population. But the success of such a strategy is dependent on the ability of community NGOs to engage with all cohorts of society, which is not guaranteed.

A notable feature of recent public protests related to the climate and biodiversity crises, compared to other political issues, is the widespread involvement of younger generations. This indicates a willingness by younger generations to engage on environmental issues (Bandura & Cherry, 2019; Boulianne et al., 2020). In this regard, efforts to widen the reach of engagement events and specifically target under-represented cohorts of the population is recommended. Enhancing advertising channels or exploring new approaches to

engagement may be necessary. For example, a more intense use of social networks might encourage the engagement of younger people. Another option to foster pro-environmental behaviours is to integrate existing events and activities with other initiatives of social influence (Schultz et al., 2008).

4.2 | Participation in community-led events

The analysis clearly indicates a strong relationship between attendance at engagement events and commitment to water quality initiatives. Water quality engagement event participants are more likely to organise their own water quality event, be members of water quality group, or take part in citizen science initiatives. This result is robust across treatments. Some ATE estimates are in excess of 0.40, which means that event attendees are 40 percentage points more likely to engage in water groups or initiatives compared to non-attendees. While LAWPRO's engagement initiatives may be considered successful to encourage community participation in water protection, it should be noted that the ATE estimates specific to LAWPRO events (T3, Table 3) are not substantially different compared to non-LAWPRO types of engagement events (i.e. T4 and T5, Table 3). Building community participation in water protection initiatives is a complex and time-consuming endeavour, while the metrics used here to measure participation in community-led events are relatively simple (i.e. survey responses C1, C2 and C3). Therefore, drawing a definitive conclusion on the relative efficacy of LAWPRO and non-LAWPRO initiatives may be beyond the scope of what is feasible here. A robust evaluation of the programme needs comprehensive data on programme inputs, as well as, quantitative demonstrative metrics of outcomes. It is imperative that programmes seeking to encourage behavioural change also contemporaneously collect data to quantitatively evaluate their success.

4.3 | Increasing knowledge and changing behaviours

All behaviours are not equally amenable to change, hence the varying measured impacts of engagement programmes on different behavioural outcomes. While individuals can be encouraged to adopt some new behaviours following the provision of relevant information, the relationship is complex. Some new behaviours can be undertaken with minimal additional effort or cost. For example, conserving water within the home may have negligible additional cost or effort but reduces water abstraction pressures on the environment. In the context of water-related community engagements, the provision of information increased water conservation activities by in excess of 10 percentage points relative to the control groups for treatments T1 and T2. Avoiding the use of in-sink food waste macerators, which reduces the nutrient load on wastewater treatment plants, is another example of the positive impact of community engagements, with a 7–9 percentage point reduction in their use relative to the control

groups for treatments T1 and T2. However, some behaviours may be less amenable to change even when there is an obvious water quality impact. This arises because long-standing or routine behaviours are very difficult to change and some habits require considerable effort to encourage the adoption of sustainable alternatives beyond just provision of information. An example is flushing wipes and other polluting items down the toilet where the estimated ATE is statistically insignificant (R1.2). Another example where the estimated ATE is statistically insignificant is not using chemicals (e.g. glyphosate) in the garden (R2.2). In these latter cases, the failure to encourage switching from a long-standing behaviour may be because people do not perceive that there are alternatives that are either similarly priced, convenient, or equally efficient.

All the examples cited in the previous paragraph, whether successful or not in changing behaviours, have low costs associated with the new behaviour. There is mixed success also when new behaviours entail substantial and unavoidable financial costs for households. Regular septic tank maintenance or private well testing are two such examples. Engagement activities are associated with a 10–12 percentage point increase in private well testing relative to the control groups for treatments T1 and T2 but the ATE in the case of septic tank maintenance is statistically insignificant. Why did behaviour change occur in one instance but not the other? A possible explanation is that detection of poor drinking water quality has a direct private benefit whereas the impact of poor septic tank operation on ground water quality is neither immediately obvious and may not have a direct private impact. While further research is necessary, behavioural change programmes may be more successful where there is an associated private benefit additional to any wider environmental or community benefits.

Does a higher number of community engagement events have a greater impact on participants? From the results presented in Table 5, the answer is nominally yes, as across the 3 categories of behaviours considered, the ATE under treatment T2 is always higher than under T1. But the 95% confidence intervals for the ATE estimates overlap to a substantial degree, which means that there is not statistical support to conclusively answer yes.

4.3.1 | Farms and other workplaces

The number of farmers within the dataset is relatively low, just 63 observations in our treatment group, therefore caution should be exercised in extrapolating any findings more generally. Across the different treatments and four farming-related behaviours considered (R6.1–R6.4), the stand-out findings relate to treatment T3, which is meetings facilitated by LAWPRO. Only in the case of treatment T3 are there three statistically significant ATE estimates. For the other event types, T4 and T5, there is no instance where the ATE estimate is statistically significant though the sample sizes in these cases are very low. Engagement events facilitated by LAWPRO appear to make a significant impact with respect to good farm practices for nutrient management. This is a promising outcome but whether the finding is



specific to the sample or more widely applicable is subject to future research.

While most water quality community engagement events target either community organisations in the case of LAWPRO events, or private individuals otherwise, the impacts are not confined to people's personal behaviours. The impacts are also noticeable in the working environment, as clearly illustrated in the results reported in Table 5. Possibly what is most significant about the findings from workplace behaviours is the cross-over from engagement events targeting private individuals and communities. A question for future research is whether the cross-over would operate in the opposite direction? If water quality engagement events target workplaces, which are likely to comprise a broader representation of the adult population, would employees embrace more sustainable behaviours in their personal lives?

4.4 | Behavioural change and engagement event types

The extant literature suggests that the different approaches utilised within behavioural change programmes can have different levels of success (Bessette, 2020; Grilli & Curtis, 2021; McKenzie-Mohr, 2000). The simple provision of information is not adequate to encourage a sustained behaviour in many instances unless the educational material provided matches pre-existing beliefs and dispositions (Carmi et al., 2015; Frantz & Mayer, 2014). The optimal choice of behavioural change approach is usually context-dependent and is contingent on the type of desired behaviours (Grilli & Curtis, 2021). To comprehensively evaluate methodological approaches would ideally require relevant data collection to be incorporated into programme implementation rather than retrospectively, as in the current case. In the current analysis only broad methodological approaches are investigated, as detailed information describing the specific formats and content of engagements is not available.

The current analysis considers three event types, T3–T5, that can be classified into two of the five approaches for encouraging pro-environmental behaviours. The nature-themed public events (T4) and community groups meetings (T5), which provide information to participants about water quality and catchment management, are considered 'education and awareness raising'. Though T4 and T5 are both classed as 'education and awareness raising', the composition of the events can be substantially different, hence the separation of the two treatments for this analysis. Nature-themed public events (T4) are often active in nature, for example, tours of water ecosystems. Community group meetings (T5) could be considered more passive in nature, often comprising a formal chaired meeting, with information conveyed to a receptive audience, or sometimes in the format of a seminar. The results in Table 5 suggest that both of these 'education and awareness raising' formats lead to a change in private behaviours relative to control groups with ATE estimates of 1.1 and 0.87 mean additional behaviours, though the point estimates are not statistically different

The public meetings facilitated by LAWPRO (T3) focus on community ties and building relationships to achieve a common community objective related to water quality and catchment management and are considered an 'outreach and community building' approach. Similar to earlier event types, T4 and T5, LAWPRO facilitated events are associated with behavioural change, with mean number of additional behaviours compared to a control group of 0.5. LAWPRO achieves success in that regard but the ATE point estimate is less than those for T4 and T5, 50% lower in the case of T4. As noted earlier, with relatively large standard errors the 95% confidence intervals for the point estimates overlap to a substantial degree, so additional evidence is necessary to conclusively draw distinctions on the relative merits of different event types. Nonetheless, the point estimates suggest that some formats used in either nature themed public events or community groups meetings might be beneficially adopted within LAWPRO events. In the absence of detailed information on the format of the different event types, more precise recommendations are not possible.

4.5 | Longevity of changed behaviours

The evidence from the analysis is that changes in behaviour are not sustained indefinitely. With respect to single behaviours (i.e. R1.1–R5.1), there are four behaviours with an ATE estimate statistically significant at the 5% level when the most recent event was in 2019 or 2020 (T7) but none when the most recent event was in 2017 or 2018 (T6). On summing across behaviours (R1.C + R2.C + R3.C), the mean sum of new behaviours is just less than 1 for T7 and not significantly different than zero for T6 compared to their respective control groups. These findings confirm the phenomena prevalent in many behavioural change programmes that behaviours tend to revert to original practice with the passage of time (Hunter et al., 2015; Luong et al., 2021; Rodda et al., 2017), though there is evidence that changed behaviours can persist over time (Maki et al., 2016; Mitchell et al., 2020). An implication for behaviour change programmes is that strategies to re-engage people on a recurring basis are also needed, perhaps using mechanisms common in other behavioural change programmes, such as community update reports or cross-community competitions (Grilli & Curtis, 2021). In the context of the wider behaviour change literature this study adds to what is a relatively small number of quantitative assessments of ORB type interventions, as noted by (Grilli & Curtis, 2021). While the analysis above identified clear quantitative outcome metrics what is also clear is that encouraging communities to change behaviours, especially related to water quality, is extremely difficult, as is measuring their progress.

4.6 | Study limitations

The study attempts to evaluate the impact of a behavioural change programme using only *ex post* data collection, which is a limitation. There is no baseline information on behaviours available for

difference-in-difference comparison though the methodological approach followed addresses this limitation. Ideally data should be collected contemporaneous with implementation of the behavioural change programme rather than retrospectively. Such an approach would facilitate more granular data on the format and composition of engagement events, which would enable further insights on what aspects are more effective in encouraging people to change their behaviours.

Many organisations seek to improve water quality and independently of each other attempt to engage with members of society. This makes it challenging to isolate the specific contribution of LAWPRO initiatives in changing behaviours. Our methodological approach was to capture all types of public engagement events that people may have experienced, as ignoring third party influences on people's behaviours would be misleading. For instance, of the surveyed participants in the LAWPRO events, just under half also attended other non-LAWPRO water-related events. Furthermore, while the ultimate objective of LAWPRO's initiatives is that Ireland will achieve 'good' ecological status in water bodies by 2027, the behaviours investigated here represent a small part of a complex, multifaceted plan to deliver on the objective.

5 | CONCLUSION

Five research questions were posed with respect to Irish community engagement and behavioural change programme to encourage communities to take responsibility for water quality and catchment management in their locality. Invariably there are individual successes within the programme but a significant challenge in answering the research questions is the lack of sufficient data collection capturing relevant metrics to enable an assessment. A contribution of this paper is the application of econometric techniques for policy impact evaluation using an ex post treatment and control experiment for data collection. A propensity score matching technique is performed to address the non-experimental nature of the data and achieve a better estimation of the average treatment effect of the behavioural change programmes.

The first research question asks whether LAWPRO's activities successfully connect with the wider public. Participants at LAWPRO events are characterised as being older, well educated, financially comfortable, and with a high likelihood of representing an NGO, such as a local community, sports, or environmental organisation. Accordingly, it is likely that LAWPRO's initiatives are overlooking a wide section of society. The high level of engagement with participants that are representing NGOs is a triumph for LAWPRO, particularly as LAWPRO's strategy is to galvanise local community groups to take responsibility for water quality and catchment management in their area. It is feasible that the socio-demographic traits of NGO representatives (i.e. being older, well educated, financially comfortable) are not reflective of the membership of their NGOs and in that circumstance the potential reach of LAWPRO's activities is wider than suggested by the analysis here.

A second question aims to understand whether attendance at water quality engagement activities is reflected in greater participation in water protection related events within communities. In this regard, indications are that event attendance encourages participation in community led initiatives but the impact varies across event types. LAWPRO specifically aims to promote community involvement in water protection through local groups and community organisations but there is insufficient evidence in the analysis here to conclude that it has been more successful in this regard than community engagement initiatives by other organisations but more robust contemporaneous collection of outcome metrics is needed to fully assess the success of the programme.

A third question seeks to understand the extent to which engagement leads to improved knowledge and changed behaviours within the home and workplace. The balance of evidence is that attendance at water quality community engagement events is associated with a greater adoption of pro-environmental behaviours. All behaviours are not equally amenable to change and it is unclear why participants adopt some behaviours and not others, even among activities where sustainable alternatives have no obvious cost or effort barriers. The findings also suggest that the decision-making process is quite complex and not necessarily rational. An obstacle to improving water quality, as well as devising successful behaviour change programmes, is deciphering the motivations behind such apparently irrational decisions.

The fourth question asks which types of engagement activities are most effective in yielding behavioural change among private individuals. Whether engagement activities by LAWPRO or other organisations, all are associated with successfully encouraging behavioural change. While there were nominal differences in the average number of behaviours changed across event types within the current dataset, it is not possible to conclusively say which approach is most effective. Where engagement activities have experienced success (i.e. in relation to specific behaviours), the successful outcomes often differ across event types, which suggests organisations can learn from each other in terms of designing effective engagement programmes. One notable result with respect to the effectiveness of engagement programmes relates to farmers. The findings here suggest a strong uptake of good farming practices with respect to nutrient planning and management following participation in LAWPRO initiatives. An unexpected finding relates to other workplaces and the extent to which community focused water quality engagement activities have a cross-over impact on workplace behaviours. A question for future research is whether engagement with workplaces on water quality and environmental issues would also have a cross-over impact on private behaviours?

The final question relates to the presence of time decay effects associated with changed behaviours. There is clear evidence that behaviours examined are not sustained indefinitely, which is a result not unique to this study. The implication is that successful community engagement is not a single event or series of events, rather it is a process over an extended time-frame. Long-standing or routine behaviours are difficult to change so behavioural change programmes must



continually re-engage to help people learn sustainable alternatives. As noted in the introduction, there are many public programmes attempting to change peoples' behaviours, with most associated research occurring during the design of behavioural change initiatives (McKenzie-Mohr, 2011). Substantially less prevalent are ex post evaluations of behavioural change programmes, invariably because metrics on programme performance are often limited to resource inputs. Effective programme evaluation not only necessitates the collection of quantitative outcome metrics but also the collection of detailed activity metrics that record how resources (budgets and people) are deployed to affect behaviours. Without the former it is impossible to evaluate whether behaviours have changed. With the latter it is feasible to evaluate the efficient deployment of resources.

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ENDNOTE

¹ Though ATE estimates for some of its constituent parts are individually statistically significant, for instance, in the case of R1.C and R4.1.

REFERENCES

- DHPLG (2018). River Basin Management Plan for Ireland (2018–2021). Department of Housing, Planning, Community and Local Government, Dublin. <https://www.housing.gov.ie/sites/default/files/publications/files/rbmpreportenglishwebversionfinal0.pdf>
- Abadie, A., & Imbens, G. W. (2006). Large sample properties of matching estimators for average treatment effects. *Econometrica*, 74(1), 235–267. <https://doi.org/10.1111/j.1468-0262.2006.00655.x>
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Aljerf, L., & Choukaife, A. (2016). Sustainable development in Damascus university: A survey of internal stakeholder views. *Journal of Environmental Studies*, 2(2), 1–12.
- Angrist, J. D., & Pischke, J.-S. (2008). *Mostly harmless econometrics: An empiricist's companion*. Princeton University Press.
- Austin, P. C. (2010). Statistical criteria for selecting the optimal number of untreated subjects matched to each treated subject when using many-to-one matching on the propensity score. *American Journal of Epidemiology*, 172(9), 1092–1097.
- Austin, P. C. (2014). A comparison of 12 algorithms for matching on the propensity score. *Statistics in Medicine*, 33(6), 1057–1069. <https://doi.org/10.1002/sim.6004>
- Axon, S., Morrissey, J., Aiesha, R., Hillman, J., Revez, A., Lennon, B., Salel, M., Dunphy, N., & Boo, E. (2018). The human factor: Classification of European community-based behaviour change initiatives. *Journal of Cleaner Production*, 182, 567–586. <https://doi.org/10.1016/j.jclepro.2018.01.232>
- Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes*, 50(2), 248–287. [https://doi.org/10.1016/0749-5978\(91\)90022-L](https://doi.org/10.1016/0749-5978(91)90022-L)
- Bandura, A., & Cherry, L. (2019). Enlisting the power of youth for climate change. *The American Psychologist*, 75, 945–951. <https://doi.org/10.1037/amp0000512>
- Barr, S., Gilg, A., & Shaw, G. (2011). 'Helping people make better choices': Exploring the behaviour change agenda for environmental sustainability. *Applied Geography*, 31(2), 712–720. <https://doi.org/10.1016/j.apgeog.2010.12.003>
- Bessette, G. (2020). Participatory development communication and natural resources management. In J. Servaes (Ed.), *Handbook of communication for development and social change* (pp. 1141–1154). Springer.
- Bethlehem, J. (2010). Selection bias in web surveys. *International Statistical Review*, 78(2), 161–188.
- Black, D. A., & Smith, J. A. (2004). How robust is the evidence on the effects of college quality? Evidence from matching. *Journal of Econometrics*, 121(1–2), 99–124. <https://doi.org/10.1016/j.jeconom.2003.10.006>
- Boulianne, S., Lalancette, M., & Ilkiw, D. (2020). "School strike 4 climate": Social media and the international youth protest on climate change. *Media and Communication*, 8(2), 208–218. <https://doi.org/10.17645/mac.v8i2.2768>
- Cameron, A. C., & Trivedi, P. K. (2005). *Microeconometrics: Methods and applications*. Cambridge University Press.
- Carmi, N., Arnon, S., & Orion, N. (2015). Transforming environmental knowledge into behavior: The mediating role of environmental emotions. *The Journal of Environmental Education*, 46(3), 183–201.
- Cooper, R. J., Hiscock, K. M., & Lovett, A. A. (2019). Mitigation measures for water pollution and flooding. In *Landscape planning with ecosystem services* (pp. 359–379). Springer. <https://doi.org/10.1007/978-94-024-1681-723>
- Darnton, A. (2008). *Government social research (GSR) behaviour change knowledge review*. Government Social Research Unit, HM Treasury. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/498064/Behaviour-changepracticalguidecm6-9696.pdf
- Doyle, R., & Davies, A. R. (2013). Towards sustainable household consumption: Exploring a practice oriented, participatory backcasting approach for sustainable home heating practices in Ireland. *Journal of Cleaner Production*, 48, 260–271. <https://doi.org/10.1016/j.jclepro.2012.12.015>
- EEA. (2018). European waters: Assessment of status and pressures 2018. *European Environment Agency*, 7, 1–90. <https://doi.org/10.2800/303664>
- Espinosa, A., & Walker, J. (2013). Complexity management in practice: A viable system model intervention in an Irish eco-community. *European Journal of Operational Research*, 225(1), 118–129. <https://doi.org/10.1016/j.ejor.2012.09.015>
- Frantz, C. M., & Mayer, F. S. (2014). The importance of connection to nature in assessing environmental education programs. *Studies in Educational Evaluation*, 41, 85–89.
- Greene, W. H. (2003). *Econometric analysis* (5th ed.). Prentice Hall.
- Grilli, G., & Curtis, J. (2021). Encouraging pro-environmental behaviours: A review of methods and approaches. *Renewable and Sustainable Energy Reviews*, 135, 110039. <https://doi.org/10.1016/j.rser.2020.110039>
- Howells, M., Hermann, S., Welsch, M., Bazilian, M., Segerstrom, R., Alfstad, T., Gielen, D., Rogner, H., Fischer, G., Van Velthuisen, H., Wiberg, D., Young, C., Alexander Roehrl, R., Mueller, A., Steduto, P., & Ramma, I. (2013). Integrated analysis of climate change, land-use, energy and water strategies. *Nature Climate Change*, 3(7), 621–626. <https://doi.org/10.1038/nclimate1789>
- Hunter, R. F., Christian, H., Veitch, J., Astell-Burt, T., Hipp, J. A., & Schipperijn, J. (2015). The impact of interventions to promote physical activity in urban green space: A systematic review and

- recommendations for future research. *Social Science & Medicine*, 124, 246–256. <https://doi.org/10.1016/j.socscimed.2014.11.051>
- Inman, A., Winter, M., Wheeler, R., Vrain, E., Lovett, A., Collins, A., Jones, I., Johns, P., & Cleasby, W. (2018). An exploration of individual, social and material factors influencing Water pollution mitigation behaviours within the farming community. *Land Use Policy*, 70, 16–26. <https://doi.org/10.1016/j.landusepol.2017.09.042>
- IPBES. (2019). Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the intergovernmental science-policy platform on biodiversity and ecosystem services. *The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*, 1, 1–60. <https://doi.org/10.5281/zenodo.3553579>
- IPCC. (2014). *Climate change 2014: Synthesis report. Contribution of working groups I, II and III to the fifth assessment report of the intergovernmental panel on climate change*. Intergovernmental Panel on Climate Change. <https://www.ipcc.ch/report/ar5/syr/>
- Luong, M.-L. N., Hall, M., Bennell, K. L., Kasza, J., Harris, A., & Hinman, R. S. (2021). The impact of financial incentives on physical activity: A systematic review and meta-analysis. *American Journal of Health Promotion*, 35(2), 236–249. <https://doi.org/10.1177/0890117120940133>
- Maki, A., Burns, R. J., Ha, L., & Rothman, A. J. (2016). Paying people to protect the environment: A meta-analysis of financial incentive interventions to promote proenvironmental behaviors. *Journal of Environmental Psychology*, 47, 242–255.
- Maynard, L., Monroe, M. C., Jacobson, S. K., & Savage, A. (2020). Maximizing biodiversity conservation through behavior change strategies. *Conservation Science and Practice*, 2(6), e193. <https://doi.org/10.1111/csp2.193>
- McKenzie-Mohr, D. (2000). New ways to promote proenvironmental behavior: Promoting sustainable behavior: An introduction to community-based social marketing. *Journal of Social Issues*, 56(3), 543–554. <https://doi.org/10.1111/0022-4537.00183>
- McKenzie-Mohr, D. (2011). *Fostering sustainable behavior: An introduction to community-based social marketing*. New Society Publishers.
- Michie, S., Johnston, M., Francis, J., Hardeman, W., & Eccles, M. (2008). From theory to intervention: Mapping theoretically derived behavioural determinants to behaviour change techniques. *Applied Psychology*, 57(4), 660–680. <https://doi.org/10.1111/j.1464-0597.2008.00341.x>
- Mitchell, M. S., Orstad, S. L., Biswas, A., Oh, P. I., Jay, M., Pakosh, M. T., & Faulkner, G. (2020). Financial incentives for physical activity in adults: Systematic review and meta-analysis. *British Journal of Sports Medicine*, 54(21), 1259–1268. <https://doi.org/10.1136/bjsports-2019-100633>
- NIEA (2012). Effecting Behaviour Change Through Environmental Messaging. Northern Ireland Environment Agency. <https://www.nienvironmentlink.org/cmsfiles/files/Publications/Behaviour-Change-EnvMsging.pdf>
- Poortinga, W., & Whitaker, L. (2018). Promoting the use of reusable coffee cups through environmental messaging, the provision of alternatives and financial incentives. *Sustainability*, 10(3), 873.
- Prochaska, J. O., & Velicer, W. F. (1997). The transtheoretical model of health behavior change. *American Journal of Health Promotion*, 12(1), 38–48. <https://doi.org/10.4278/0890-1171-12.1.38>
- Rajapaksa, D., Gifford, R., Torgler, B., Garcia-Valin˜as, M., Athukorala, W., Managi, S., & Wilson, C. (2019). Do monetary and non-monetary incentives influence environmental attitudes and behavior? Evidence from an experimental analysis. *Resources, Conservation and Recycling*, 149, 168–176.
- Redmond, P., & McGuinness, S. (2019). The gender wage gap in Europe: Job preferences, gender convergence and distributional effects. *Oxford Bulletin of Economics and Statistics*, 81(3), 564–587. <https://doi.org/10.1111/obes.12282>
- Rodda, S. N., Lubman, D., Jackson, A., & Dowling, N. A. (2017). Improved outcomes following a single session web-based intervention for problem gambling. *Journal of Gambling Studies*, 33(1), 283–299. <https://doi.org/10.1007/s10899-016-9638-2>
- Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70(1), 41–55. <https://doi.org/10.1093/biomet/70.1.41>
- Schultz, W. P., Khazian, A. M., & Zaleski, A. C. (2008). Using normative social influence to promote conservation among hotel guests. *Social Influence*, 3(1), 4–23. <https://doi.org/10.1080/15534510701755614>
- Sekhon, J. S. (2011). Multivariate and propensity score matching software with automated balance optimization: The matching package for r. *Journal of Statistical Software*, 42(7), 1–52. <https://doi.org/10.18637/jss.v042.i07>
- Victoria, T. (2002). Theories and models of behaviour change. Melbourne, Australia, Victorian State Government <http://www.ncongo.info/wp-content/uploads/2011/05/Theories-and-models-of-behaviourchange.pdf>
- Wallen, K. E., & Daut, E. (2018). The challenge and opportunity of behaviour change methods and frameworks to reduce demand for illegal wildlife. *Nature Conservation*, 26, 55–75. <https://doi.org/10.3897/natureconservation.26.22725>
- Zhang, Z., Hu, Z., & Liu, C. (2019). Estimating the population average treatment effect in observational studies with choice-based sampling. *The International Journal of Biostatistics*, 15(1), 1–29. <https://doi.org/10.1515/ijb-2018-0093>

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