

Scotland's Rural College

Understanding farmers' intentions to follow a nutrient management plan using the theory of planned behaviour

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1 1. Introduction

2 Farmer decision making surrounding the use of agricultural nutrient inputs, such as chemical
3 fertiliser and manure, is a critical issue and of significant importance to policy makers (Sutton
4 *et al.*, 2013; McGlynn *et al.*, 2018). Nutrient application to agricultural fields has contributed
5 to substantial improvements in crop yields, which have led to a significant increase in the
6 ability of the earth to sustain more humans (Smil, 2002). However, inefficient or over-use of
7 nutrient inputs has led to significant negative environmental and social impacts (Tilman,
8 1999; Jones *et al.*, 2014; Wagena and Easton, 2018). On the other hand, under-application of
9 nutrients can contribute to declining levels of soil fertility and below expected crop yields
10 (Bai *et al.*, 2013) and, ultimately, an under-utilisation of productive agricultural land. Both
11 over and under-application of nutrients to crops can also lead to financial losses to farmers
12 (Buckley and Carney, 2013). Therefore, from both a policy and societal perspective, it is of
13 paramount importance that farmers manage nutrient inputs properly and efficiently in order to
14 minimise the risk of nutrient loss to the environment, whilst also ensuring that natural
15 resource use is optimised and appropriate soil fertility levels are maintained (Jakrawatana *et*
16 *al.*, 2017; Macintosh *et al.*, 2019).

17 To mitigate the negative impacts associated with inefficient nutrient use and improve farm
18 incomes, farmers are encouraged to adopt various recommended management strategies
19 (Price *et al.*, 2011; Micha *et al.*, 2018). One important and widely promoted management
20 practice is nutrient management planning (Osmond *et al.*, 2015; Ulrich-Schad *et al.*, 2017).
21 Nutrient management planning is a process which involves using farm-specific data to
22 formulate a written plan (document) also known as a nutrient management plan (NMP),
23 typically with an agricultural advisor (Beegle *et al.*, 2000). The purpose of an NMP is to
24 ensure that nutrients are applied in the right quantities, at the right time, in the right place and
25 using the right source (Genskow, 2012; Roberts and Johnston, 2015). Use of NMPs have
26 been associated with environmental and financial benefits due to improvements in the way in
27 which fertiliser and manure is managed on farms (Thomas *et al.*, 2007; Amon-Armah *et al.*,
28 2013). However, despite proven benefits and considerable promotion, development of NMPs
29 remains below expectations globally (Lawley *et al.*, 2009; Buckley *et al.*, 2015; Osmond *et*
30 *al.*, 2015; Ulrich-Schad *et al.*, 2017; Brown *et al.*, 2019). Moreover, a situation has been
31 observed whereby farmers who develop a NMP do not necessarily follow the plan (Osmond
32 *et al.*, 2015). Therefore, the focus of this study is on farmers' intentions to follow a NMP
33 rather than a mere examination of the development of a NMP.

34 Several socioeconomic variables, such as farm system, farm size and farmer age, are
35 suggested in the literature to examine the low levels of uptake of management practices, such
36 as NMPs (Prokopy *et al.*, 2008; Baumgart-Getz *et al.*, 2012; Brown *et al.*, 2019). However,
37 there remains a lack of clear evidence as to why farmers choose to follow a NMP (Ulrich-
38 Schad *et al.*, 2017). Moreover, there is a general dis-satisfaction across the literature with the
39 ability of previous studies to provide a comprehensive understanding of farmer decision
40 making (Edwards-Jones, 2006; Feola *et al.*, 2015; Zeweld *et al.*, 2017). This is possibly due
41 to the poor level of conceptualisation, inconsistent measurement and lack of a theoretical
42 basis for the inclusion of socio-psychological issues, such as attitudes and social pressure, in
43 the analysis of farmer decision making (Burton, 2004, Hansson *et al.*, 2012; Borges and Oude
44 Lansink, 2016). Once such aspects are taken into account, the influence of socio-economic
45 variables on adoption tends to lose explanatory power (Poppenborg and Koellner, 2013). For
46 this reason, there has been a growing shift towards incorporating theoretical frameworks from
47 social psychology to improve the understanding of farmer decision making and to use these

48 insights to better inform policy design (Borges *et al.*, 2014; Adnan *et al.*, 2017; Floress *et al.*,
49 2017). One such theoretical model that has received considerable interest in the literature is
50 the Theory of Planned Behaviour (TPB) (Ajzen, 1991).

51 The TPB suggests that an individual's decision to engage in a particular behaviour is
52 primarily driven by their intentions, which are in turn affected by three independent
53 constructs: attitude, subjective norm (social pressure) and perceived behavioural control
54 (ease/difficulty) (Ajzen, 1991). There is wide support for the TPB across the literature
55 (Armitage and Conner, 2001; Fielding *et al.*, 2005; Hansson *et al.*, 2012; Lappler and Kelley,
56 2013; Hyland *et al.*, 2018; Adnan *et al.*, 2018; Rezaei *et al.*, 2018; Wang *et al.*, 2019).
57 Despite this, there are a number of limitations of past applications of the TPB in an
58 agricultural context. Firstly, whilst a number of authors, such as Sok *et al.* (2016) and Morais
59 *et al.* (2018), have examined inter-relationships between the TPB constructs, these studies
60 focus on examining correlations instead of causal pathways. That is, Sok *et al.* (2016) and
61 Morais *et al.* (2018) did not investigate the specific direction of influence between the TPB
62 constructs and the likely reasons for these relationships. Secondly, previous studies within an
63 agricultural context often fail to explore how institutional factors may influence farmers'
64 attitudes, subjective norms and perceived behavioural control (Bijttebier *et al.*, 2018).
65 Institutional variables, such as communication, extension, education and policy are potential
66 levers that can stimulate behavioural change (Barnes *et al.*, 2013).

67 This study extends the literature by providing an understanding of the causal relationships
68 between, and institutional influences on, the TPB constructs in relation to farmers' intentions
69 to follow a NMP. This method enables the provision of a more comprehensive insight into
70 farmer decision making which can be used to inform policy that is designed to encourage
71 further use of NMPs at a global scale.

72 The objectives of this study are as follows: 1) to identify the effect of attitude, subjective
73 norm and perceived behavioural control on farmers' intentions towards following a NMP, 2)
74 to explore relevant causal inter-relationships between the TPB constructs and 3) to investigate
75 institutional influences on farmers' attitudes, subjective norm and perceived behavioural
76 control. These objectives are fulfilled by analysing Irish survey data collected as part of a
77 wider research project (see Daxini *et al.*, 2018 for further detail).

78 2. Theoretical framework and hypotheses

79 In order to address the three main research objectives of this paper, we develop a theoretical
80 framework based on the TPB (Ajzen, 1985; Ajzen, 1991).

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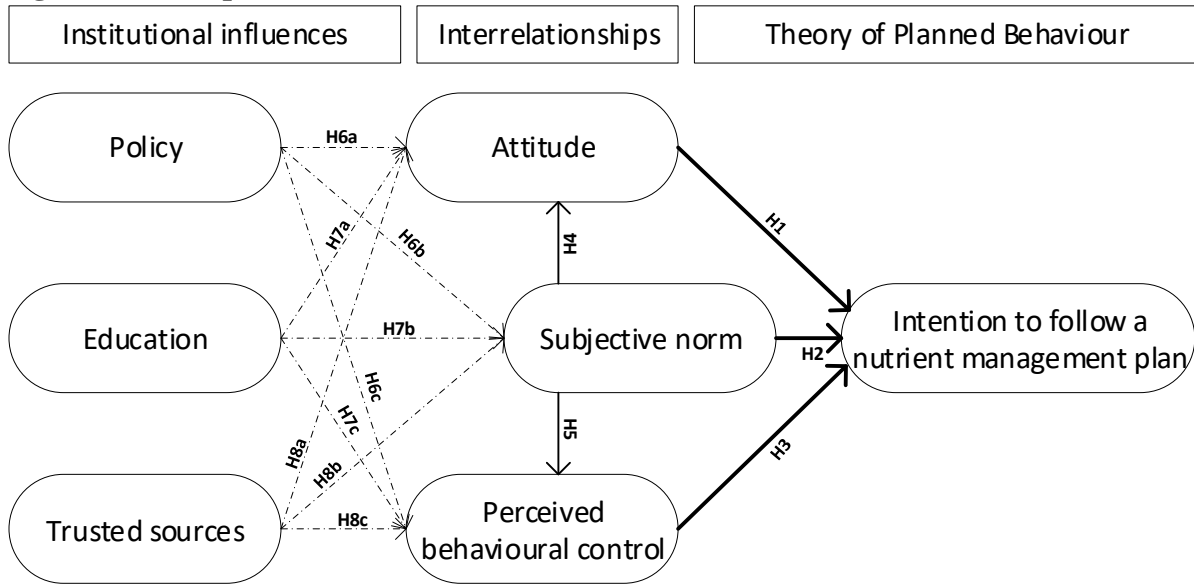
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89 **Figure 1: Conceptual framework based on the TPB**



90

91 The TPB, which is an extension of the Theory of Reasoned Action (TRA) (Fishbein and
 92 Ajzen, 1975), attempts to explain and understand why an individual may undertake a certain
 93 behaviour (McEachan *et al.*, 2016). According to the TPB, intention is the most important
 94 predictor of behaviour, which relates to an individual’s motivation or willingness to invest
 95 effort in performing the behaviour (Ajzen, 2002; Bamberg *et al.*, 2007). The greater the
 96 intention, the more likely an individual is to enact the behaviour. Intention, in turn, is
 97 determined by three socio-psychological constructs: attitude, subjective norm and perceived
 98 behavioural control (Ajzen, 1991).

99 In line with the TPB (Ajzen, 1991), attitude is defined as a positive or negative evaluation of
 100 performing a given behaviour. Thus, the intention of farmers to follow a NMP will increase if
 101 they perceive that using this practice is useful and beneficial and will lead to positive results
 102 for them. Subjective norm encapsulates the level of social pressure or expectations felt by an
 103 individual from significant reference persons to engage or not to engage in a particular
 104 behaviour. It is argued that people tend to conform to subjective norms due to a fear of social
 105 exclusion (Bamberg and Möser, 2007). Thus, if farmers feel that people whose opinion they
 106 value confirm a given behaviour then their own intention to perform the behaviour should
 107 increase (Rezaei *et al.*, 2018). Finally, perceived behavioural control is an individual’s
 108 perception of the ease or difficulty related to their performing a given behaviour, which is
 109 also related to the presence of facilitating conditions, sometimes referred to as situational
 110 constraints (Ajzen, 2002; Bamberg and Möser, 2007). This construct reflects the extent to
 111 which an individual perceives that the behaviour in question is under his/her volitional
 112 control (Ajzen, 1991). Therefore, farmers’ intentions to follow a NMP should increase as the
 113 degree of their perceived control over performing this behaviour becomes greater (Adnan *et al.*,
 114 2017). As a general rule of thumb, the more positive the attitude, subjective norm and
 115 perceived behavioural control, the greater the likelihood of adopting the behaviour in
 116 question (Ajzen, 1991).

117 Previous research has shown that attitude, subjective norm and perceived behavioural control
 118 are positively associated with farmers’ intentions to adopt riparian zone management in
 119 Australia (Fielding *et al.*, 2005), improved grassland management in Brazil (Borges *et al.*,
 120 2014) and on farm food safety management in Iran (Rezaei *et al.*, 2018). However, Wauters

121 *et al.* (2010) only found attitude to be an important factor determining farmers' intentions to
122 adopt soil management practices in Belgium. Elsewhere, Hyland *et al.* (2018) confirmed the
123 importance of attitude and perceived behavioural control, but did not find subjective norm to
124 be a significant determinant of farmers' intentions to adopt grazing management practices in
125 Ireland. Typically, the influence of the TPB constructs on intentions varies depending on the
126 behaviour and context under study (Ajzen, 1991). Finally, although not applying the TPB,
127 various studies have also confirmed the importance of farmers' attitudes (Flett *et al.*, 2004;
128 Reimer *et al.*, 2012), social pressures (Welch and Marc-Aurele, 2001; Ribaudo and
129 Johansson, 2007; Yoshida *et al.*, 2018) and perceptions of control or efficacy (Zhang *et al.*,
130 2016; Wilson *et al.*, 2018) in the decision to adopt various nutrient management practices.

131 Founded on the assumptions of the TPB and based on the literature above, we develop the
132 following hypotheses:

133 **H1.** Attitude has a positive influence on farmers' intentions towards following a NMP.

134 **H2.** Subjective norm has a positive influence on farmers' intentions towards following a
135 NMP.

136 **H3.** Perceived behavioural control has a positive influence on farmers' intentions towards
137 following a NMP.

138 *Inter-relationships between the TPB constructs*

139 Whilst the TPB framework has three independent socio-psychological constructs that
140 influence intentions, results from previous studies also indicate that the TPB constructs are
141 correlated (Trafimow and Finlay, 2001; Bamberg and Möser, 2007; Quintal *et al.*, 2010
142 Borges and Oude Lansink, 2016; Morais *et al.*, 2018). Here, we focus on examining two key
143 causal relationships between the TPB constructs which pertain to the influence of subjective
144 norms on attitude and perceived behavioural control. We specifically focus on these two
145 relationships and directions of influence, rather than between other constructs or directions,
146 due to wide theoretical and empirical support for these specific causal pathways (Oliver and
147 Bearden, 1985; Taylor and Todd, 1995; Bamberg *et al.*, 2007; Bamberg and Möser, 2007;
148 Quintal *et al.*, 2010; Peters *et al.*, 2011; López-Mosquera *et al.*, 2014; Park and Ha, 2014;
149 Rezaei *et al.*, 2019; Ru *et al.*, 2019).

150 Kallgren *et al.* (2000) suggest that the influence of subjective norms on behaviour possibly
151 relies less on individual's fear of social sanctions but on their use of subjective norms as an
152 easy source of information on how others validate particular behavioural options. Therefore,
153 the influence of subjective norm on attitude is in line with the notion that individuals may use
154 subjective norms for evaluating how advantageous the adoption of a given behaviour would
155 be (Bamberg and Möser, 2007). Thus, people tend to take into consideration the view of
156 important referent groups when forming their own attitudes towards a given behaviour
157 (Burton, 2004; Quintal *et al.*, 2010; López-Mosquera *et al.*, 2014). While the opposing
158 relationship is that attitudes can influence subjective norms, it has been demonstrated that it is
159 more probable that attributes of the external social environment will influence attributes of
160 the individual (Ryan, 1982; Quintal *et al.*, 2010). Schaak and Mußhoff (2018) found that
161 subjective norms positively influenced farmers' perceptions of the benefits of management
162 practices in Germany. Therefore, the fourth hypothesis is as follows:

163 **H4.** Subjective norm has a positive influence on attitude towards following a NMP.

164 In a similar fashion, it is also likely that subjective norms will influence individuals'
165 perceptions of how easy or difficult it is to perform a given behaviour (Quintal *et al.*, 2010).
166 Bamberg and Möser (2007) suggest that subjective norms also provide individuals with
167 guidance or information as to whether the behaviour is likely to be easy to perform. Thus,
168 subjective norms have an influence on individuals' perceptions of control over performing
169 the behaviour (Bamberg *et al.*, 2007). For instance, positive encouragement or approval from
170 significant others can lead to a sense of confidence (control) over performing a particular
171 behaviour (Nair and Little, 2016; Ru *et al.*, 2019). Numerous studies have also shown that
172 subjective norms, influences individuals' perceptions of confidence and potential external
173 impediments to acting, thus confirming that subjective norms influence perceived control
174 over performing a given behaviour (Quintal *et al.*, 2010; Peters *et al.*, 2011; Sánchez *et al.*,
175 2018). Overall, this suggests that external social pressure originating from what others
176 believe, can influence individuals' perceptions of the ease or difficulty in acting and facilitate
177 the way in which individual's act (López-Mosquera *et al.*, 2014) and, therefore we assume
178 the following hypothesis:

179 **H5.** Subjective norms have a positive influence on perceived behavioural control over
180 following a NMP.

181 *Influence of institutional variables on the TPB constructs*

182 In order to promote behavioural change, the mere knowledge of the influence of the TPB
183 constructs on intentions is not always sufficient (Ajzen, 2011; Bijttebier *et al.*, 2018). Rather,
184 an understanding of the key variables which are likely to influence farmers' attitudes,
185 subjective norms and perceived behavioural control must also be developed. Such variables
186 can include policy, education and trusted information sources (Bosch *et al.*, 1995; Blackstock
187 *et al.*, 2010; Aarts and Lokhorst, 2012; Lam *et al.*, 2017). We treat these variables as
188 'institutional variables' which leads to the development of H6, H7 and H8 which are
189 presented below.

190 *Policy*

191 Certain nutrient management policies, such as the Nitrates Directive (ND) in the European
192 Union (EU), require certain farmers to develop a NMP on a mandatory basis (European
193 Commission, 1991). Whilst research has shown that policy can increase the number of NMPs
194 that are developed (Savage and Ribaud, 2013; Perez, 2015), this does not always translate
195 into use of such plans (Osmond *et al.*, 2015). It thus remains inconclusive as to whether
196 policy, which requires the mandatory development of NMPs, is an effective tool for
197 encouraging farmers to follow such plans. Therefore, it is interesting to explore the potential
198 effect of policy on attitude, subjective norm and perceived behavioural control in order to
199 inform more effective policy design.

200 Buckley (2012) found that a number of farmers, who displayed positive attitudes towards the
201 ND policy in Ireland, believed that the policy had led to positive farm management benefits
202 and agreed that the policy had made them more aware of the nutrient requirements of their
203 crops and stimulated them to improve the way in which they plan the use of fertilisers on
204 their farm. Elsewhere, Macgregor and Warren (2015) found that over time, farmers' attitudes
205 towards the ND regulation improved in Scotland. Farmers who are subject to policy
206 requirements, which require them to develop a NMP on a mandatory basis, may also feel a
207 higher degree of social pressure to follow the plan. Policy makers can make the development
208 of a NMP mandatory by using policy compliance as a tool and imposing financial penalties

209 on those farmers who do not develop a plan if they are required to do so. However,
210 monitoring the use of NMPs is difficult and hard to regulate (Perez, 2015). Nevertheless,
211 farmers who are obliged to develop a NMP on a mandatory basis may feel a higher degree of
212 social pressure to follow the plan. This pressure may arise from the desire of the farmer, who
213 is subject to policy compliance requirements, to go above and beyond the requirements in
214 order to receive the approval and respect of significant others with whom they interact
215 (Grasmick & Bursik, 1990). Examples of likely sources of such social pressure include other
216 farmers subject to mandatory policy requirements, agricultural advisors, the media and
217 family. Moreover, over time, such desires may have a socialising effect on the farmers who
218 develop a NMP on a mandatory basis which may lead to a shift in norms and further
219 normative commitment towards following a NMP (Winter & May, 2001). Finally, farmers
220 subject to mandatory policy requirements are also often provided with additional education
221 and training regarding the use of NMPs, which tends to have a positive influence on the use
222 of NMPs due to improved confidence and technical ability in relation to use (Osmond *et al.*,
223 2015). Thus, we assume the following hypotheses:

224 **H6a** Policy has a positive influence on farmers' attitude towards following a NMP.

225 **H6b** Policy has a positive influence on subjective norm.

226 **H6c** Policy has a positive influence on farmers' perceived behavioural control over following
227 a NMP.

228 *Formal education*

229 Formal education has the ability to foster positive attitudes towards the use of nutrient
230 management practices, as it helps to increase understanding of complex issues (Bosch *et al.*,
231 1995). Education can also foster positive attitudes by helping to dispel myths about the
232 outcomes of performing a given behaviour. For Bourdieu (1986), education is a form of
233 cultural capital, while Burton and Paragahawewa (2011) observe a connection between
234 education and the level of cultural capital possessed by an individual. Cultural capital
235 contributes to status generation, often through improved management skills (Burton, 2014).
236 Education can thus lead individuals to be drawn into behaving in ways that are socially
237 acceptable. Finally, education is also known to increase efficacy of farm management
238 through improvement in technical abilities or improvements in understanding of management
239 issues such as nutrient management planning (Burton, 2014). Thus we hypothesise that:

240 **H7a** Education has a positive influence on farmers' attitude towards following a NMP.

241 **H7b** Education has a positive influence on subjective norm.

242 **H7c** Education has a positive influence on farmers' perceived behavioural control over
243 following a NMP.

244 *Trusted information sources*

245 Information sources that farmers trust, such as agricultural advisors, other farmers, family
246 and the media, play an important role in shaping farmers' attitudes and perceptions towards
247 the adoption of management practices (Sutherland *et al.*, 2013; Hunecke *et al.*, 2017; Liu *et al.*,
248 2018). Trust is an important concept as it is viewed as a catalyst that encourages the
249 conversion of information into usable knowledge (Fisher, 2013). Moreover, the ability to

250 change attitudes and the success of information interventions depends on individual's trust in
251 the source of the message (Blackstock *et al.*, 2010). Therefore, the type of information
252 sources that are trusted by farmers and their likely influence on perceptions towards
253 management practices, are also important to consider (Gervais *et al.*, 2001; Genius *et al.*,
254 2006; Stuart *et al.*, 2014). For example, trust in a professional agricultural advisor would
255 generally be reassuring and have a strong, positive influence on attitudes, social pressure felt
256 and perceptions of control over following a NMP (Genius *et al.*, 2006; Wilson *et al.*, 2018).
257 Whereas, this effect may not be as strong for the media or other farmers, who might have
258 mixed opinions regarding the use of NMPs. For example, Zeweld *et al.* (2017) found that
259 technical training and important referent groups, such as family, neighbours and friends,
260 increased farmers' levels of social pressure to adopt sustainable management practices,
261 whereas the media did not have a significant influence. Zeweld *et al.* (2017) also
262 demonstrated a positive influence between technical training and farmers' attitudes towards
263 such practices. We therefore propose the following hypotheses:

264 **H8a** Farmers' levels of trust in information sources is positively and significantly associated
265 with their attitudes towards following a NMP.

266 **H8b** Farmers' levels of trust in information sources has a positive and significant influence
267 on subjective norm.

268 **H8c** Farmers' levels of trust in information sources has a positive and significant correlation
269 with perceived behavioural control over following a NMP.

270 3. Methodology

271 *Survey*

272 The data used for the purpose of this study were derived using the same survey and sample of
273 Irish farmers described in Daxini *et al.* (2018). A structured survey was designed to collect
274 information pertaining to the socio-demographic characteristics of the sample, trusted
275 information sources and a series of items were used to measure the TPB constructs. The
276 content of the survey was developed based on a literature review of past TPB research in an
277 agricultural domain (e.g. Läpple and Kelley, 2013; Borges *et al.*, 2014; Micha *et al.*, 2015;
278 Lalani *et al.*, 2016; van Dijk *et al.*, 2016), previous survey experience of the authors and a
279 series of preliminary interviews (Francis *et al.*, 2004; Sutton *et al.*, 2004). These interviews
280 were conducted with farmers and agricultural advisors prior to the development of the survey
281 and were designed to reveal key attitudes and perceptions towards following a NMP. Prior to
282 the administration of the survey, a pilot test was conducted and, as a result, minor
283 amendments were made to the wording of some of the questions.

284 The data were collected between the months of January to April 2017 using face-to-face
285 interviews with farmers. Survey recorders read out the questions to respondents who were the
286 main decision maker on the farm. A total of 1009 farmers were interviewed. To ensure that
287 the sample of farmers was representative, the survey company first stratified the sample by
288 Electoral Divisions (Howley, 2013). At each sampling point, the interviewer followed a quota
289 controlled system based upon the known proportion of farm systems and sizes within each
290 area. Interviewers then continued to interview farmers until they filled their quotas. Quota
291 controlled sampling is a non-probability sampling method which guarantees that the sample
292 has the same proportions of individuals as the entire population in relation to a set of
293 specified characteristics (Elder, 2009). For the purpose of this study, the quota was designed

294 in order to ensure that the sample was representative of Irish farming by farm systems and
295 sizes. The quotas used for the purpose of this study were based on known national population
296 figures in relation to specific farm types (Hennessy and Moran, 2015).

297 *Variables*

298 *Theory of Planned Behaviour (TPB)*

299 The TPB constructs (attitude, subjective norm, perceived behavioural control and intention)
300 are considered to be latent constructs and therefore must be measured using multiple items
301 (Hair *et al.*, 2010). By using multiple items, the measurement error of a particular variable is
302 minimised and the statistical estimation of the associations between the variables improved
303 (Borges and Oude Lansink, 2016). The items were based on information collected during the
304 development of the survey. Overall, 14 items are used to measure the TPB constructs:
305 attitude, subjective norms, perceived behavioural control and intentions. These items are all
306 anchored on a 5-point Likert scale from strongly disagree (1) to strongly agree (5), which are
307 regarded as short enough to allow respondents to distinguish meaningfully between the
308 categories (Hansson *et al.*, 2012).

309 *Policy*

310 A policy variable is developed which describes farmers who are required to develop a NMP
311 on a mandatory basis. In Ireland, these farmers include those who receive a ‘derogation’
312 (allowance) under the ND to farm at a higher stocking rate or participate in the ‘Green Low
313 Carbon Agricultural Environment Scheme’ (GLAS). A dummy variable is developed to
314 reflect farmers who participate in policy (1) against those who do not (0).

315 *Formal education*

316 Education is measured on a 5-point Likert scale with increasing levels of formal educational
317 attainment from primary level (1), some secondary level (2), completed secondary level (i.e.
318 obtained leaving certificate) (3), professional diploma (4) and higher education (5).

319 *Trusted information sources*

320 As discussed previously, farmers are influenced by a range of information sources. In order to
321 understand the influence of different information sources, farmers were asked to respond on a
322 5-point Likert scale from very unlikely (1) to very likely (5) to the question: “how likely are
323 you to follow advice from the following people/sources regarding nutrient management on
324 your farm?” The response options included: ‘family’; ‘discussion group’; ‘agricultural
325 advisor’; ‘other farmers’; ‘scientific literature’; ‘farming press and magazines’; ‘information
326 events’ such as farm walks, open days and demonstration events and the ‘media’ such as TV
327 and radio. It is important to identify the underlying structure and commonalities in trust
328 preferences. To achieve this aim, we employed a principal component analysis (PCA) which
329 was rotated using the varimax method.

330 The suitability of the data for PCA is initially checked using a Kaiser-Meyer-Olkin measure,
331 giving a value of 0.86, indicating suitability (Kaiser, 1974). Furthermore, the Bartlett’s test of
332 Sphericity gave a value of 0.0000, which suggests that there is a significant relationship
333 between the variables. The decision regarding the number of components to retain is based on
334 evaluating the eigen values, where values above 1 should be retained (Hair *et al.*, 2010).

335 Based on the eigen values we retain a total of two components. We also decide to allow
 336 items to load onto components (factor loadings) with coefficients of above 0.3 (see Table 1)
 337 (Hair *et al.*, 2010). Finally, the internal consistency of the components is checked using
 338 Cronbach's alpha. The values of each component are both over the recommended threshold
 339 value of 0.5 (Nunnally, 1978). The final components can be used as independent variables in
 340 the SEM in place of the original items, with the knowledge that significant variation in the
 341 original data has not been lost, but that the derived variables are uncorrelated thus avoiding
 342 any possible issues with multicollinearity (Howley, 2013).

343 **Table 1: Principal components - trusted information sources (factor loadings >0.3**
 344 **highlighted in bold).**

Trusted source	Technical information	Social information
Family	-0.05	0.43
Agricultural advisor	0.46	-0.07
Discussion group	0.48	0.00
Other farmers	-0.05	0.51
Scientific literature	0.34	0.14
Farming press	0.08	0.47
Information event	0.40	0.11
Media	-0.02	0.54
Agricultural training course	0.51	-0.08
<i>Eigen value</i>	4.3	1.1

345 The results of the PCA (Table 1) are interpreted on the basis of the type of information source
 346 that farmers are more likely to trust. Component one reflects farmers who are more likely to
 347 trust advice from 'technical' sources of information, which includes agricultural advisors,
 348 discussion groups, agricultural training courses and information events. On the other hand,
 349 component two comprises farmers who are more likely to trust advice from 'social' sources
 350 which includes other farmers, family, agricultural press and the media. Subsequently we label
 351 component one as 'technical information' and component two as 'social information'.
 352 Importantly, this leads to a modification of the hypothesised conceptual framework which
 353 decomposes the variable 'trusted sources' into two separate forms of 'trusted sources' which
 354 are: 'technical information' and 'social information'.

355 Following the results of the PCA we revise H8a, H8b and H8 and the additional H9a, H9b
 356 and H9c are also formulated as follows:

357 **H8a:** Farmers' levels of trust in technical information sources are positively and significantly
 358 correlated with farmers' attitudes towards following a NMP.

359 **H8b:** There is a positive and significant correlation between farmers' levels of trust in
 360 technical information sources and subjective norms.

361 **H8c:** Farmers' levels of trust in technical information sources has a positive and significant
 362 influence on farmers' perceived behavioural control over following a NMP.

363 **H9a:** Farmers' levels of trust in social information sources has a positive influence on
 364 farmers' attitudes towards to following a NMP.

365 **H9b:** The higher the level of farmer's trust in social information sources, the more positive
 366 their level of subjective norm will be.

367 **H9c:** Farmers’ levels of trust in social information sources has a positive and significant
 368 influence on farmers’ perceived behavioural control over following a NMP.

369 *Data analysis*

370 Structural equation modelling (SEM) is adopted to test the proposed research hypotheses.
 371 SEM is a commonly used technique to test models with observed and latent variables (Toma
 372 *et al.*, 2013). A two-step procedure is adopted to test the research hypotheses (Anderson and
 373 Gerbing, 1988). In the first step, confirmatory factors analysis (CFA) is used to assess the fit
 374 of the measurement model and assess the reliability and validity of the constructs. In the
 375 second step, the structural model is used to test the hypothesised relationships. Because the
 376 skew and kurtosis statistics demonstrated deviations from normality assumptions, the model
 377 is estimated using the Satorra–Bentler method which is robust against violations of non-
 378 normality (Satorra and Bentler, 1994; Kline, 2011).

379 4. Results

380 *Socio-economic characteristics of the sample*

381 The majority (51%) of respondents in the sample are cattle farmers, 26% are dairy, 17% are
 382 sheep and around 6% are tillage. The median farm size is 31 to 50 hectares. In terms of age,
 383 the median is 51 to 64 years old. These figures are in line with national averages (Hennessy
 384 and Moran, 2015). The farmers in the sample have a high level of farming experience with a
 385 mean of 36 years of experience. In relation to the highest level of formal education attained,
 386 around 16% have a primary level of education, 30% have some secondary level of education,
 387 34% have formally completed secondary level (leaving certificate obtained), 13% have
 388 received a professional diploma and only 7% have acquired a university degree. Due to
 389 policy requirements, 42% of farmers are obliged to develop a NMP on a mandatory basis. In
 390 terms of intentions, on average, 67% of farmers either agree or strongly agree that they have
 391 an intention to follow a NMP in the near future.

392 *Descriptive statistics of the measured items*

393 Table 2 presents an overview of the measured items and illustrates that farmers show a
 394 moderately positive intention to follow a NMP. The three items used to measure intention
 395 have a mean of 3.65. In general, farmers also show a positive attitude towards following a
 396 NMP, with a mean score of 3.98 for the items used to measure attitude. Farmers stated that
 397 they felt a moderately high level of social pressure to follow a NMP with a mean of 3.71
 398 between the items used to measure subjective norm. Finally, in relation to perceived
 399 behavioural control, farmers revealed a positive level of control with a mean of 3.91 among
 400 the items used to measure this construct.

401 **Table 2: Descriptive statistics of the items used to measure the TPB constructs and**
 402 **results of the measurement model**

Item measure	Mean	Standard deviation	Item loadings	CR	AVE
Attitude				0.96	0.86
In your opinion, following a NMP is: a good idea?	4.01	0.67	0.93***		
In your opinion, following a NMP is: useful?	4.00	0.67	0.94***		
In your opinion, following a NMP is: reliable?	3.98	0.68	0.91***		
In your opinion, following a NMP is: important?	3.94	0.75	0.92***		
Subjective norm				0.92	0.80
When it comes to following a NMP, most people whose	3.80	0.74	0.87***		

opinion I value regarding farming: would approve if I do so?					
When it comes to following a NMP, most people whose opinion I value regarding farming: encourage me to do so?	3.62	0.89	0.91***		
When it comes to following a NMP, most people whose opinion I value regarding farming: think that I should do so?	3.71	0.81	0.90***		
Perceived behavioural control				0.87	0.68
When it comes to following a NMP: I am confident in my ability to do so?	3.97	0.74	0.87***		
When it comes to following a NMP: it is easy to do so?	3.87	0.77	0.82***		
When it comes to following a NMP: I have a clear understanding of how to do so?	3.95	0.79	0.79***		
Intention				0.97	0.93
When it comes to following a NMP in the near future: I intend to do so?	3.62	1.02	0.98***		
When it comes to following a NMP in the near future: it is likely that I will do so?	3.63	1.01	0.98***		
When it comes to following a NMP in the near future: I would consider doing so?	3.71	0.98	0.94***		

Notes: CR = Composite reliability, AVE = Average variance extracted. ***P < 0.01.

403 *Measurement model*

404 The results of the CFA (Table 2) show that all of the standardised factor loadings are
405 statistically significant ($p < 0.01$) and are all above the recommended threshold value of 0.70
406 (Hair *et al.*, 2010). In terms of model fit, given the over-sensitivity of the chi-square test to
407 sample size, we utilise other fit statistics which account for the bias against large samples (de
408 Leeuw *et al.*, 2015; Martinovska Stojcheska *et al.*, 2016). These fit indices include the
409 Comparative fit index (CFI = 0.993), Tucker-Lewis index (TLI = 0.991), Root mean square
410 error of approximation (RMSEA = 0.031) and Standardized root mean square residual
411 (SRMR = 0.023). Each of these values conforms with recommended limits (CFI/TLI > 0.95;
412 RMSEA/SRMR < 0.08) and therefore we conclude that the model has good fit to the data
413 (Hu and Bentler, 1995; Hair *et al.*, 2010).

414 All of the latent constructs are assessed for both reliability and validity. Reliability is
415 associated with the internal consistency of the multiple indicators used to measure each
416 construct (López-Mosquera *et al.*, 2014). The composite reliability (CR) scores are between
417 0.87 and 0.97, which are all above the acceptable value of 0.70 (Hair *et al.*, 2010). Validity is
418 associated with the degree to which the observed variables accurately measure the intended
419 construct (Li *et al.*, 2018). We measure validity using both convergent and discriminant
420 validity (Fornell and Larcker, 1981). The average variance extracted (AVE) is estimated for
421 each construct to measure convergent validity. The AVE value must exceed a threshold value
422 of 0.50 (Hair *et al.*, 2010). All AVE scores are between 0.68 and 0.93, suggesting suitable
423 convergent validity. Discriminant validity is confirmed as the AVE values for each construct
424 are found to be greater than the square of the corresponding inter-construct correlations (see
425 Table 3) (Sharifzadeh *et al.*, 2017).

426 **Table 3: Inter-construct squared correlations and AVE (along the diagonal)**

Factor	ATT	SN	PBC	INT
ATT	0.86			
SN	0.34	0.80		
PBC	0.52	0.35	0.68	
INT	0.47	0.44	0.53	0.93

Notes: ATT = Attitude; SN = Subjective norm; PBC = Perceived behavioural control; INT = Intention.

427 We also check for multicollinearity between the variables in the model by computing
 428 variance inflation factors (VIF). A maximum VIF value of 3.43 is found, which is below the
 429 recommended threshold value of 10 which suggests that multicollinearity is not an issue in
 430 our model (Hair *et al.*, 2010).

431 *Structural model*

432 The goodness of fit indices of the structural model are as follows: CFI (0.970), TLI (0.961),
 433 RMSEA (0.072) and SRMR (0.079). The fit indices are within the recommended thresholds
 434 and therefore they indicate suitable model fit (Hair *et al.*, 2010). Table 4 shows the results of
 435 the hypothesis testing results which are presented as standardised path coefficients which
 436 show the significance and strength of association between the variables in the hypothesised
 437 relationships (Hair *et al.*, 2010). In terms of the influence of attitude, subjective norm and
 438 perceived behavioural control on intention, each construct has a positive and significant
 439 influence on intentions. This leads us to accept H1, H2 and H3. However, the coefficients
 440 also reveal that perceived behavioural control has the greatest effect on intentions (0.37)
 441 followed by subjective norm (0.30) and then attitude (0.28).

442 In relation to the inter-relationships between the TPB constructs, subjective norm is
 443 positively and significantly associated with attitude (0.47). Likewise, subjective norm
 444 positively influences perceived behavioural control (0.46). Thus the results of the inter-
 445 relationships examined between the TPB constructs leads us to accept H4 and H5.

446 The results also indicate that the institutional variable policy, has a significant effect on
 447 attitude (0.09), subjective norm (0.11) and perceived behavioural control (0.14). This offers
 448 support for H6a, H6b and H6c. Education is only significantly and positively related to
 449 perceived behavioural control, although the magnitude of the influence is relatively small
 450 (0.08). Thus, we accept H7c but reject both H7a and H7b. The effect of trust in technical
 451 information sources on attitude (0.14) and perceived behavioural control (0.16) is positive
 452 and significant, however this variable has the largest influence on subjective norm (0.46).
 453 This leads us to accept H8a, H8b and H8c. Finally, trust in social information sources is
 454 positively and significantly associated with attitude (0.09) and a relatively larger influence is
 455 found on subjective norm (0.11) compared to attitude. Based on this result we reject H9c but
 456 accept H9a and H9b.

457 **Table 4: Hypothesis testing results**

Hypotheses	Path	Standardized estimate	S.E	P	Result
<i>TPB</i>					
H1	ATT → INT	0.28	0.03	***	Accept
H2	SN → INT	0.30	0.05	***	Accept
H3	PBC → INT	0.37	0.04	***	Accept
<i>Inter-relationships</i>					
H4	SN → ATT	0.47	0.04	***	Accept
H5	SN → PBC	0.46	0.04	***	Accept
<i>Institutional influences</i>					
H6a	Policy → ATT	0.09	0.03	***	Accept
H6b	Policy → SN	0.11	0.03	***	Accept
H6c	Policy → PBC	0.14	0.03	***	Accept
H7a	Education → ATT	0.00	0.02	NS	Reject
H7b	Education → SN	-0.02	0.03	NS	Reject
H7c	Education → PBC	0.08	0.03	**	Accept

H8a	Trust (Technical information) → ATT	0.14	0.04	***	Accept
H8b	Trust (Technical information) → SN	0.46	0.04	***	Accept
H8c	Trust (Technical information) → PBC	0.16	0.04	***	Accept
H9a	Trust (Social information) → ATT	0.09	0.04	**	Accept
H9b	Trust (Social information) → SN	0.11	0.04	***	Accept
H9c	Trust (Social information) → PBC	0.05	0.04	NS	Reject

Notes: ATT = Attitude; SN = Subjective norm; PBC = Perceived behavioural control; INT = Intention; NS = Not significant. **p < 0.05, ***p < 0.01.

458 5. Discussion and conclusion

459 Understanding the socio-psychology of the decision making process of farmers is critical to
460 encouraging further use of beneficial management practices, such as nutrient management
461 planning (Blackstock *et al.*, 2010; Okumah *et al.*, 2018). However, without understanding the
462 complexity of the formation of attitudes and perceptions and how institutional variables (e.g.
463 policy, education and information sources) may contribute to these formations, it is difficult
464 to design effective policy and behavioural change solutions (Fleming *et al.*, 2010; Bijttebier
465 *et al.*, 2018). The results of this study show that the majority of the hypotheses are validated
466 which confirms the importance of considering both internal (attitudes and perceptions) and
467 external (policy and information) drivers of farmers' decision making processes (Edwards-
468 Jones, 2006; Feola and Binder, 2010; Mills *et al.*, 2018).

469 The results demonstrate that perceived behavioural control is the most important determinant
470 of intentions to follow a NMP, which implies that farmers' perceptions of the level of
471 easiness, self-confidence and degree of control over following a NMP is important in
472 determining the intention to follow one. Nutrient management planning is a technical
473 management practice which requires specialist knowledge, skill and attention to detail and
474 therefore is often considered to be among the more complex of farm management practices
475 (Beegle *et al.*, 2000; Walters and Shrubsole, 2014). Madden *et al.* (1992) suggest that
476 perceived behavioural control typically plays a significant role in determining intention to
477 perform a given behaviour when engagement in that behaviour is difficult. Whilst agricultural
478 advisors typically support farmers in an EU context, not all farmers engage with advisors and
479 therefore they may not feel competent or confident to follow a NMP (Kania *et al.*, 2014).
480 This could lead to a continued reliance on intuitive judgement instead of using formalised
481 NMPs (Nuthall and Old, 2018). Previous studies have also shown that perceived behavioural
482 control and efficacy are particularly important determinants of nutrient management practice
483 adoption (Wilson *et al.*, 2014; Zhang *et al.*, 2016; Wilson *et al.*, 2018).

484 Previous studies have found subjective norm to be a particularly important determinant of
485 farmers' intentions towards adopting, for example, improved grassland management (Borges
486 *et al.*, 2014), diversified agricultural production (Senger *et al.*, 2017) and grazing
487 management practices (Schaak and Mußhoff, 2018). The results of this study also confirm the
488 important influence of subjective norm on farmers' intentions to follow a NMP. This means
489 that farmers who feel a higher degree of social pressure or approval to follow a NMP are
490 more likely to do so. This may be due to a fear of social exclusion from not conforming to
491 what is deemed to be good practice (Bamberg and Möser, 2007). Burton (2004) explains that
492 subjective norms influence intentions and behaviours because individuals do not make
493 decisions without considering their actions in relation to that of others, nor are individuals
494 independent of social and cultural influences. Moreover, the highly influential role of
495 subjective norms in our study may be related to an increase in focus on improving nutrient
496 management on farms in recent years, which may have stimulated an increase in social

497 pressure on farmers to voluntarily use best management practices, such as NMPs (Savage and
498 Ribaudo, 2013; Reimer *et al.*, 2018).

499 The influence of attitude on intentions is positive and significant which implies that farmers
500 who view the outcomes of following a NMP more favourably, are more likely to have a
501 positive intention to follow a plan. This result supports previous TPB studies which found
502 attitude to be an important determinant of farmers' intentions to adopt various agricultural
503 practices (Wauters *et al.*, 2010; Zeweld *et al.*, 2017; Hyland *et al.*, 2018). However, it has
504 been well-established that attitudes are not, in themselves, adequate for the prediction of
505 individual's intentions (Floress *et al.*, 2017). Our result also implies that farmers' evaluation
506 of the importance and benefits of following a NMP are perhaps less important than their
507 ability and the social pressure felt towards following a NMP. For example, Trafimow and
508 Finlay (2001) argue that depending on the behaviour in question, people can be more
509 attitude-driven or subjective norm driven. When it comes to following a NMP, farmers are
510 perhaps more motivated by external social pressures over their own internal opinions
511 (attitude). Burton (2004) suggests that people often push aside their personal opinions and
512 rational considerations in favour of the views of important referent groups. Our result also
513 resonates with the findings of Yoshida *et al.* (2018) who demonstrated that farmers often
514 forgo their own attitudes in favour of external social pressures and demands on production.

515 A number of inter-relationships are also examined between the TPB constructs. As
516 mentioned previously, the results confirm the positive significant influence of subjective
517 norm on attitude, thereby confirming the results of previous studies (Bamberg and Möser,
518 2007; Zhang *et al.*, 2017; Rezaei *et al.*, 2019). This suggests that farmers' attitudes towards
519 following a NMP are represented by social considerations. Petty and Cacioppo (1996) put
520 forward the argument that individuals' attitudes are influenced by other individuals and the
521 environment around them. Likewise, Quintal *et al.* (2010) assert that individuals consider
522 others' expectations when they form their personal attitudes. It is likely that farmers are using
523 subjective norms as a source of information to evaluate how advantageous following a NMP
524 may be, which may be contributing to attitude formation (Bamberg and Möser, 2007). This
525 relationship may be further explained by the fact that there is no absolute definition of what a
526 correct attitude is (Fetsinger, 1954), and therefore, individuals' views of what important
527 referent groups expect of them may influence their attitudes towards a certain practice (Park
528 and Ha, 2014).

529 Subjective norm is also found to positively and significantly influence perceived behavioural
530 control. This means that farmers who feel a higher degree of social pressure and/or
531 encouragement to follow a NMP are more likely to perceive a greater degree of control over
532 doing so. The result supports the notion that that external social pressure or encouragement
533 arising from the opinions of others can facilitate perceptions of how easy or difficult farmers
534 feel, in this case, it is to follow a NMP (Bamberg and Möser, 2007). Thus, in terms of
535 following a NMP, it is probable that farmers are evaluating how easy it is to do so through an
536 evaluation of other farmers' perceptions (Bamberg *et al.*, 2007). Quintal *et al.* (2010) also
537 suggest that the exertion of social pressure on individuals to behave in a certain way can
538 influence their understanding of the barriers to carrying out the behaviour in question.
539 Therefore, positive encouragement or approval from individuals whose opinions are valued
540 by farmers, may result in an increase in confidence in following a NMP due to a decrease in
541 the perceptions of the magnitude of the barriers that may exist (Nair and Little, 2016; Ru *et*
542 *al.*, 2019). The effect of subjective norm on perceived behavioural control has also been
543 confirmed by previous studies (Peters *et al.*, 2011; Park and Ha, 2014; Rezaei *et al.*, 2019).

544 Farmers who are obliged to develop a NMP on a mandatory basis are more likely to feel a
545 higher degree of social pressure and level of control over following the plan. One potential
546 explanation for these results relates to the nature of policy requirements in Ireland. Farmers
547 must have a NMP developed by a qualified agricultural advisor to comply with GLAS or ND
548 derogation requirements. Furthermore, farmers participating in GLAS must attend specific
549 agricultural training courses where nutrient management planning forms a part of the course
550 (DAFM, 2017). Previous research has shown that engagement with advice and support
551 systems can help stimulate interest, responsibility and a sense of personal and social norm
552 (Dwyer *et al.*, 2007; Mills *et al.*, 2016) as well as improve control over following a NMP
553 (Osmond *et al.*, 2015). Policy also has significant positive influence on farmers' attitudes
554 towards following a NMP, but this relationship is weak.

555 A positive, but weak, association is found between education and perceived behavioural
556 control. Nutrient management planning is a technical process and requires attention to detail
557 and the ability to comprehend the complexities associated with optimising nutrient use
558 (Beegle *et al.*, 2000). A probable explanation for this result is that education increases
559 efficacy of farm management through an enhancement of technical skills and familiarity
560 required to use technical innovations, such as NMPs (Burton, 2014).

561 The findings also suggest that trust in technical sources of information has a critical influence
562 on subjective norm followed by perceived behavioural control and attitude; whereas, trust in
563 social sources has a positive influence on subjective norm and attitude only. Importantly,
564 trust in technical sources has a higher magnitude of influence on the TPB constructs than
565 social sources. This suggests that expertise and professional sources are more crucial in terms
566 of the development of farmers' perceptions, than generalist sources such as family and the
567 media. Blackstock *et al.* (2010) suggest that the higher the credibility of the advice source,
568 (such as people from farming backgrounds or trusted networks), the higher the persuasion
569 factor will be. O'Keefe (2016) argues that highly credible sources, such as approved advisors,
570 are often important when messages or procedures are complex. Following a NMP requires
571 the initial collection and then synthesis of farm specific data such as stocking rate, soil
572 fertility and yield potential (Beegle *et al.*, 2000). Thus, technical assistance is often crucial,
573 especially in terms of the synthesis, interpretation and formulation of a NMP and guidance
574 for following the plan (Osmond *et al.*, 2015).

575 This study extends the literature by examining the socio-psychological determinants of
576 farmers' intentions to follow a NMP whilst also examining the causal relationships between,
577 and institutional influences on, the TPB constructs. We argue that this approach is better
578 suited to understanding the complexities of farmer decision making and prescribing potential
579 policy and behavioural change intervention strategies.

580 The main policy implication emerging from the results relates to the importance of perceived
581 behavioural control and subjective norm which was not only shown to directly influence
582 farmers' intentions but also farmer's attitudes and perceptions of control over following a
583 NMP. Thus, we suggest that it is crucial that policy makers continue to explore novel ways of
584 improving farmers' own capabilities over following a NMP and increasing social pressure on
585 farmers to follow a NMP as a way to establish long term norms. Overall, in line with others
586 (Feola *et al.*, 2015; Wang *et al.*, 2019), we stress the importance of continuing to develop an
587 understanding of farmer psychology in relation to the use of management practices that have
588 the ability to provide both environmental and financial benefits. Without doing so, solutions
589 may be prescribed that are not geared towards maximising the influence they have on
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