Identifying factors that support sustainable farming practice change: Application of Theory of Planned Behaviour in project evaluation

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Abstract. To achieve water quality targets needed to support the ecological restoration of the Great Barrier Reef, increased uptake of programs aiming to change farming practices is needed. However, notwithstanding extensive research and progress in this area, knowledge gaps may be limiting the potential effectiveness of initiatives. Of particular significance is the relative paucity of reliable evidence on social and psychological factors that are theoretically known to influence the performance of a person's behaviour. This paper reports an application of the Theory of Planned Behaviour to evaluate intentions, perceived behavioural control, attitudes and social norms in changing farming practices following participation in a project aiming to enhance water quality. Overall, 23.5 % of the variance in self-reported framing practices were explained by the Theory of Planned Behaviour. The results are consistent with previous research on the influence of social norms in the adoption of behaviours, supporting a role for including social and psychological variables in farming practice change research, while simultaneously acknowledging the need for further research to draw definitive conclusions.

Keywords: farming practices, theory, social norms, social factors, Great Barrier Reef

Background

Since 2015 the Reef 2050 Long Term Sustainability Plan (Australian Government & Queensland Government 2015), a joint plan between the Australian and Queensland Governments that was endorsed by the World Heritage Committee, has served as a shared blueprint for managing the Reef and improving its health and resilience. The Reef 2050 Plan outlines a partnership approach implemented with governments, Traditional Landowners, the community, industry and scientists. In 2017 concern was expressed about progress made to date towards achieving water quality targets (Waterhouse et al. 2017). Calls were made for acceleration in approaches to ensure that the intermediate and long-term targets outlined in the Plan could be met.

Sediment and chemical run-off from farms into waterways can be reduced and a co-ordinated response across stakeholder groups is needed to realise the outcomes sought. Over past decades a considerable number of programs and projects have been implemented with the aim of improving the ecological health of the Great Barrier Reef (GBR). Many of these programs and projects have focused on changing farming practice to reduce loads of catchment-sourced stressors, principally nutrients, fine sediment and pesticides which act to reduce Reef resilience (State of Queensland 2018). Programs have also sought to incentivise land use changes – such as wetland conversion and wetland restoration – which can actively reduce nutrient, sediment and pesticide loads delivered to the GBR Lagoon.

Considerable quantities of data have been collected on these programs, tracking expenditures, detailing voluntary uptake of programs across the agricultural sector and, to a lesser extent, recording outcomes in the Reef Lagoon. The Reef 2050 Water Quality Improvement Plan 2017-2022 (State of Queensland 2018) identified that **c**hanges in on-ground management, improvements to program design, delivery and evaluation systems were an urgent need, along with greater incorporation of social and economic factors, and better targeting in program delivery. Therefore, in this context, work to identify social and individual factors that enable, and support practice change represents an important undertaking. The identification and understanding of relevant social and individual factors can be advanced through the application of theory.

Theory is a set of interrelated concepts, definitions, and propositions that explain or predict events or situations by specifying relationships among variables (Glanz et al. 2008; Glanz & Bishop 2010). When applied, theory offers an organising framework for conducting research. Moreover, the methods and results of theoretically based studies are open to critical analysis and evaluation relative to predefined parameters or constructs. It is through such critical analysis and evaluation advances in any scientific field are achieved (Rothman 2004). Importantly, in the context of initiatives for behaviour change, theoretically-based research can assist in understanding why (or why not) programs and interventions are more, or less, successful. However, evidence reviews of behaviour change research have found that theory is predominantly used 'to inform' research, meaning that the explanatory or predictive power of one or more specific theories may be discussed as part of the background of the study; and at times theoretical constructs may be

selectively utilised (Pang et al. 2017; Willmott et al. 2019; Kim et al. 2020). Comparatively fewer studies are found to empirically 'apply' or 'test' whole theories in the explanation or prediction of behaviour and behaviour change. While it is acknowledged that the under-utilisation of theory may reflect incomplete reporting and inconsistent selection and definition of constructs, considerable room for improvement exists to increase the role of theory in monitoring and evaluating programs that aim to change behaviours (Rundle-Thiele et al. 2019).

Traditional and environmentally sustainable agricultural systems and practices have been extensively researched across disciplines, including economics, sociology, psychology, marketing, agricultural extension, and anthropology, producing an extensive and diverse body of literature (Pannell et al. 2006). The adoption of sustainable farming practices has been examined as a decision-making process in which a multitude of personal, social, cultural and economic factors exert influence on people's behaviours (e.g. Rogers 2003; Pannell et al. 2006; Ranjan et al. 2019). In addition, social and behavioural theories have informed conceptual explanations of agricultural decision making, most notably Diffusion of Innovations (Rogers 2003), and to some extent the Theory of Planned Behaviour (TPB) (Ajzen 1991), or its predecessor the Theory of Reasoned Action. However, until recently, the relationship between behavioural theory and the empirical evidence on adoption of sustainable farming practices has received limited scholarly attention (Small et al. 2016).

Literature reviews has been primarily focussed on the identification of factors associated with agricultural decision making, particularly those that positively influence or enable the uptake of sustainable farming practices (e.g. Pannell et al. 2006; Knowler & Bradshaw 2007; Prokopy et al. 2008; Baumgart-Getz et al. 2012; Prokopy et al. 2019; Ranjan et al. 2019). For example, in an early narrative review, Pannell et al. (2006) sought to integrate the multi-disciplinary literature and concluded that the main theme underlying landholder decision making about the adoption of conservation practices was the extent to which the practice was perceived to support the achievement of individual goals. Pannell et al. (2006) identified three sets of issues as significant in individual decisions: the process of learning and experience; the characteristics and circumstances of the landholder within their social environment; and the characteristics of the practice (Pannell et al. 2006). In contrast, based on their meta-analysis of quantitative studies across the world, Knowler and Bradshaw (2007) found that, with the exception of some support for the role of social capital, no specific factor could be said to consistently explain practice change at farm and farmer level, leading them to suggest that the context of change should be the prime consideration in conservation agriculture policy and practice. Focusing on quantitative studies undertaken in the United States on the adoption of Best Management Practices (BMP), Prokopy et al. (2008; 2019) found that as a whole the evidence reviewed was inconclusive about factors that consistently determined adoption of BMP. However, some factors were more likely to have a role than others, including social networks, access to information, increased environmental awareness, positive environmental attitudes, self-identity, some farm (land size) and farmer characteristics (age). Ranjan et al. (2019) sought to deepen understanding of motivators and barriers to adoption of BMPs in the United States through an examination of qualitative studies. Corroborating some of the findings of earlier reviews, the evidence suggested that farmer characteristics, environmental awareness, and trust in information sources were more likely to motivate adoption; whereas, farm management, negative perceptions of a conservation practice, and land tenure represented primary barriers. Reflecting the complexity of decision making, Ranjan et al. (2019) noted that the influence of economic factors, social norms, perceptions of programs, and farm characteristics, could be positive or negative depending on interactions between individual and contextual characteristics.

Common to quantitative and qualitative reviews, was the observation that use of theory in studies on the adoption of conservation practices was highly variable in terms of both frequency and precision (e.g. Prokopy et al. 2008, 2019; Ranjan et al. 2019). Notwithstanding the correspondence of likely influencing factors with focal constructs in social and behavioural theories, quantitative studies often lacked an explicit theoretical base, or applied theory selectively or imprecisely (Prokopy et al. 2008; 2019). For example, following a further analysis of data in the Prokopy et al. (2008) review, Baumgart-Getz et al. (2012) suggested that theoretically imprecise measures of behavioural constructs contributed to limited or mixed evidence for the role of some factors, including attitudes and awareness. Furthermore, research gaps were observed for some factors that are prominent in theories of behaviour and behaviour change, most notably social norms – a central construct in the Theory of Planned Behaviour (Prokopy et al. 2008; 2019). Similar issues were identified by Ranjay et al. (2019) in the qualitative evidence for BMPs in the US. While welcoming the trend for a greater role of qualitative research in exploring the complexity of farmer decision making and farming practice change, Ranjay et al. (2019) lamented the under-utilisation of established behavioural and behavioural

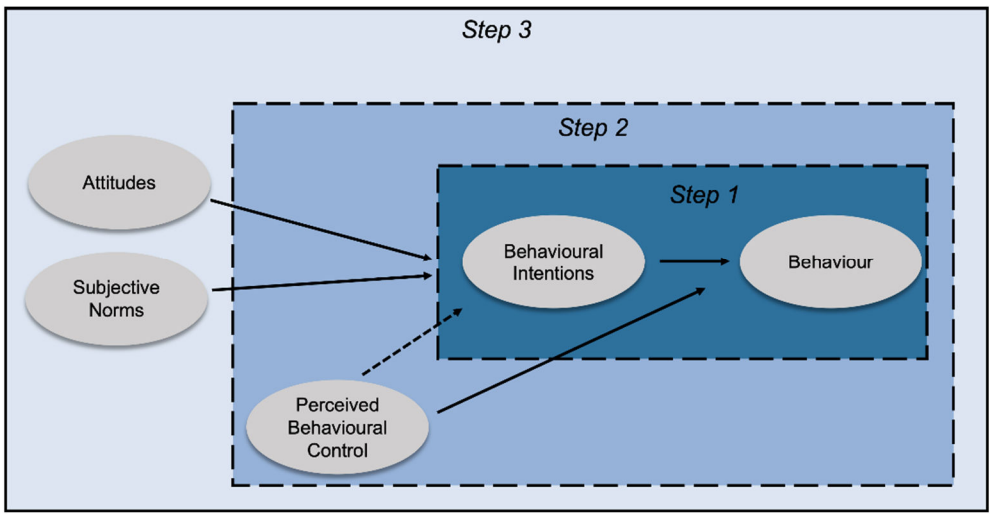
change theories that include many of the very factors that are empirically found to contribute to such complexity.

As has been found in behaviour change research generally, the most recent reviews of the literature suggest that gaps in the evidence as well as under-utilisation and incomplete reporting of behavioural theories, represent likely limitations for bringing greater clarity and extending the knowledge base on the adoption, or intention to adopt, environmentally sustainable farming practices (Small et al. 2016; Prokopy et al. 2019; Ranjan et al. 2019). The establishment of sustainable farming practices has a fundamental role in the urgent task of restoring the ecological balance of the Great Barrier Reef. The potential effectiveness of initiatives in this area will be maximised by knowing not only what factors are likely to influence practice change, but also by accessing plausible explanations of their interactions. It is through the application of theory and its evaluation across different contexts that researchers can formulate and refine plausible explanations (Prokopy et al. 2019).

Against this background, this paper contributes a case of theory applied in the evaluation of a project that aimed to achieve a reduction in nitrogen application on farms, which if achieved would contribute to improved water quality benefitting the Great Barrier Reef. The Theory of Planned Behaviour (TPB) was applied to examine the role key psycho-social variables, including intentions, perceived behavioural control, attitudes and social norms, may have on sustainable farming practices following participation in a water quality project. In assessing behavioural outcomes relative to focal constructs of the Theory of Planned Behaviour, this research sought to contribute insights on gains in effectiveness that might be expected (or not) of initiatives that specifically address TPB constructs.

The Theory of Planned Behaviour pioneered by Fishbein and Ajzen (2011) suggests that a person's performance of a specific behaviour depends on their behavioural intentions, their attitude toward the behaviour, subjective norms, and perceived behavioural control (see Figure 1). Behavioural intentions are an indication of effort and dedication towards performing the behaviour (David & Rundle-Thiele 2019). Attitude towards a behaviour is based an individual's belief about the likely outcomes of a particular behaviour. Subjective norms refer to a person's beliefs about how other people they care about would judge them if they carried out a specific behaviour. Subjective norms are closely related to social norms defined as unwritten rules about how to behave within a specific setting (Stern 2018), and have been distinguished into two types: injunctive and descriptive (Cialdini & Goldstein 2004). Injunctive social norms are generally agreed upon moral standards and beliefs shared by members of a social group, whereas descriptive social norms refer to an individual's perceptions of the behaviour of the majority in a specific situation (Berkowitz 2010; Stern 2018). Subjective norms can be influenced by a tendency to want to conform to descriptive social norms, or by social pressure associated with injunctive social norms (Stern 2018). Finally, perceived behavioural control (PBC) refers to individual beliefs of the existence or absence of resources and opportunities to execute a behaviour, and how easy or difficult the behaviour is to perform. Perceived behavioural control acts as a motivational influence on behaviour through intentions (Fishbein & Ajzen 2011).

Figure 1: The Theory of Planned Behaviour



Source: David & Rundle-Thiele (2018, p. 194)

There is a wealth of research suggesting that social norms, attitudes, and perceived behavioural control are significant socio-psychological factors across a range of human intentions and behaviours (Pickering et al. 2017; Stern 2018). It is acknowledged that there are conceptual and functional overlaps between Theory of Planned Behaviour focal constructs of intentions, attitudes, social norms and perceived behavioural control and constructs included in other established behavioural theories, including Diffusion of Innovation (Rogers 2003), the Trans-theoretical model (Prochaska & Velicer 1997) and the Health Belief Model (Rosenstock et al. 1988). More recent research emerging in behavioural economics draw from this earlier work. The Theory of Planned Behaviour was selected as a parsimonious and pragmatic choice for the purposes of this research.

Theory of Planned Behaviour constructs have been included in research on sustainable practices in agriculture (e.g. Grover & Gruver 2017; Zeweld et al. 2017; Pandey & Diwan 2018). However, to our knowledge, this has seldom been in the context of approaches or methods based entirely on the predictions of the Theory of Planned Behaviour. When the Theory of Planned Behaviour has been applied as a conceptual framework in research on the adoption of sustainable farming practices, the results have mostly supported the explanatory power of its socio-psychological constructs in different contexts. For example, Marquez-Garcia et al. (2019) compared corporate conservation behaviours in vineyards participating in a sustainability wine-farming program and non-participating vineyards. They found that participation in the sustainable winery program was positively associated with the adoption of conservation practices. Although attitudes to conservation practices were similar among the participants and non-participants, participants in the program reported positive social pressure from 20 stakeholders, which was higher than the control group that reported pressure from 11 stakeholders. Similarly, Zeweld et al. (2017) applied Theory of Planned Behaviour as a theoretical framework to analyse intentions of crop farmers to adopt conservation practices of row planting and minimum tillage[1]. Their study identified that attitudes and normative issues explained farmers' intentions to adopt both practices. However, perceived behavioural control did not have a significant effect on intention to practice row planting or to apply minimum tillage. On the other hand, perceived efficacy and perceived resources significantly influenced perceived control for minimal tillage, while only perceived efficacy significantly contributed to perceived control for row planting.

In summary, this study had multiple overlapping aims: to assess the role of Theory of Planned Behaviour specific socio-psychological factors in behavioural outcomes following participation in a practice change project; to contribute to the broader evidence base about the explanatory power of the Theory of Planned Behaviour; and, respond to recent calls for more consistent applications of theory in empirical research as a means of building reliable and valid knowledge to inform initiatives in sustainable farming.

Method

Context and rationale

The project that was evaluated featured provision of a nutrient management plan and one year of on-farm agronomic advice. The aim of this project was to provide farmers with support necessary to confidently adopt recommended best practices - including reduced fertiliser rates to align with regulation standards.

The practice change project, delivered across a government and industry partnership, worked with farmers assisting them to lower nitrogen application rates. A key focus within the project was ensuring that farmers did not compromise their productivity and profitability. The project aimed to be delivered across 90 farms over a two-year period. On-farm help valued at AU$ 5,000 worth of agronomy services including personalised one-on-one extension was a feature of this project. Agronomists visited farms to provide services including farm decision support, planning and equipment calibrations. Expected outcomes were improved nitrogen efficiencies, reduced nitrogen application, and reduced runoff into local waterways. Additional project outcomes were increased profitability and sustainability for the growers' businesses. At the time of data collection 58 growers were signed up to participate in the project.

A survey was designed to evaluate the program. Specifically, the aims of the social research survey applied to evaluate the agronomy support program were:

1. Identify why growers chose to participate in the project.
2. Understand why they have/have not changed practices.
3. Determine the likelihood of this change continuing in the future.

[1] Row planting refers to crop sequences and associations that increase species diversification. Minimum tillage involves minimal mechanical soil disturbance by direct seed and/or fertilizer placement (FAO, n.d.).

Surveys were implemented after one or two years of participation within the project. The survey incorporated one or more measures for each Theory of Planned Behaviour construct.

Sample

Following ethical clearance from the university (2018/370) surveys were administered to growers who had varying levels of experience participating in the farming practice change project. The survey was administered in 2018 to 9 growers (representing 11 farms) who commenced participation in the project in its first year. The survey was also administered to 15 growers (representing 21 farms) who commenced participation in the practice change project in its second year. Grower and farm representation were high. A total of 40% growers representing 36% of farms involved in the project were included in this study. In total, self-report data for a total of 24 growers was included in this analysis.

Design and Procedure

Informed by the Theory of Planned Behaviour the survey was designed to understand participants' experience in the three-year program that delivered extension support to enable farming practice change. Farmer beliefs and behaviours regarding participation in the extension support program are given in Table 1. Farming behaviour was measured with four self-reported behaviours including 'I have changed my farming practices'; 'I have used my technology effectively'; 'I have changed irrigation scheduling'; 'My weed management timing has changed'. All items were measured on scales ranging from "Strongly disagree" (1) to "Strongly agree" (7). Surveys were collected by extension service staff on behalf of the project team. Key Theory of Planned Behaviour measures were included in the survey, namely attitudes (4 items), perceived behavioural control (3 items), group norms (1 item), intentions (1 item) and self-reported farming practice behaviours. See Table 2 for examples of TPB constructs and measures.

Data Analysis

Following procedures reported in David and Rundle-Thiele (2018) stepwise hierarchical multiple regression (see Figure 1 and Table 3 for stepped approach) was applied to examine the explanatory potential of the Theory of Planned Behaviour to explain farming practices.

Stepwise hierarchical regression was applied because it aligns to TPB's theoretical underpinnings, namely that attitudes, social norms and perceived behavioural control interact together to influence intentions. In turn, intentions and perceived behavioural control interact together to influence behaviour.

Step 1 tested the influence that behavioural intentions had on self-reported framing practice changes behaviour. Step 2 included perceived behavioural control (perceptions of my own ability to undertake the recommended farming practices) in the model and tested the explanatory potential of intention and perceived behavioural control on behaviour. Finally, Step 3 tested all Theory of Planned Behaviour constructs, to ascertain whether the variance in behaviour explained was increased by including all Theory of Planned Behaviour constructs into the explanatory model. A hierarchical approach permitted the additive contribution of each construct to be partitioned and considered separately.

Results

Prior to statistical analyses, reliability was estimated for relevant Theory of Planned Behaviour constructs. Attitudes towards the farming practice (α = 0.85) and perceived behavioural control (α=0.86) demonstrated high internal consistency exceeding the recommended Cronbach's alpha level (α=0.70). Intentions, social norms and farming practice behaviour were measured as single items so reliability estimates were not calculated for these measures. Descriptive statistics are outlined in Table 1.

Examination of descriptive statistics indicated that growers were positive about their experiences with the farming practice change project. Of note growers agreed their profitability will improve (M=5.2) as a result of participation in the project, growers agreed that their farming practices have changed (M=5.3) and their networks have increased as a result of participating in the farming practice change project (M=5.5).

Table 1. Grower perceptions of project participation

As a result of participation in this project	Mean
I think my profitability will improve	5.2
I have changed my farming practices	5.3
My network has increased	5.5
I am happy with the progress I have made	5.9
I believe that time I've spent on the project is good use of my time	6.0
I think my soil health will improve	5.0
I have implemented a whole farm management plan	6.2
I have used my technology effectively	5.4
I have changed irrigation scheduling	5.4

Growers participating in the project were asked to report on Theory of Planned Behaviour constructs (see Table 2). Attitudes towards the farming practice were measured with two items (see Table 2). For example, the first question asked *respondents' attitudes toward the farming practice before the program*, and results showed a neutral attitude (M=4.4). Taken together results demonstrated that although growers' attitudes towards the farming practice were neutral, their intentions to continue to use the farming practice (M=6.0) were high. Moreover, growers agreed they would know how to continue the farming practice after the project (M=5.1) as measured by perceived behavioural control.

Table 2. Grower perceptions of project participation

As a result of participation in this project	Mean (Standard Deviation)
(Intentions) How likely are you to continue to use the farming practice after the project finishes?	6.0 (1.5)
(Perceived behavioural control) I am confident I can continue; I am able to continue; I can overcome obstacles faced.	5.1 (1.3)
(Attitudes toward the farming practice) I think my profitability will improve; I think my soil health will improve.	4.4 (1.7)
(Social norms) Growers in my local area who implement the farming practice are positively recognised.	5.0 (1.2)

Half (54%) of the participants (n=13) also agreed that growers implementing the recommended practices are positively recognised. Results demonstrate that 95% of respondents felt their profitability would improve.

A model of farming practice change

Results of hierarchical regressions are presented next (see Table 3). Only intention was entered in the first step, which did not explain the variance in farming practice behaviour. Step 2 accounted for 8% of variance in farming practice behaviour, with the addition of perceived behavioural control. Both models were not statistically significant. After entry of all Theory of Planned Behaviour constructs in Step 3 of the hierarchical regression, the total variance explained by the model was 23.5 % ($F(3, 19)=3.256$, $p<0.05$). The final model was statistically significant at the 5% level. The inclusion of attitude and social norms explained an additional 15.5 % of the variance in farming practice behaviour, after controlling for intention and PBC ($(1, 21)=2.910$ and $p=0.10$). Unstandardised (B) and standardised (b) regression coefficients and squared semi-partial (or "part") correlations (sr^2) for each predictor on each step of the hierarchical multiple regression are reported in Table 3. In the final step, one measure was statistically significant, social norms (p = 0.026), which had the strongest effect on intentions to continue the farming practice behaviour. The results of the adjusted R^2 for the final model show that Theory of Planned Behaviour explained 23.5% of the variance to continue the farming practice behaviour.

Table 3. Theory of Planned Behaviour Hierarchical Regression Results

Dependent Variable: Farming behaviour	***B***	**Beta**	**sr^2**	**Step 1 significance**	***B***	**Beta**	**sr^2**	**Step 2 significance**	***B***	**Beta**	**sr^2**	**Step 3 significance**
Constant	5.4				3.5			0.018	1.8			0.322
Intentions	-0.037	-0.042	-0.0	0.848	-0.2	-0.2	-0.2	0.319			-0.2	5.300
Perceived behavioural control					0.4	0.3	0.4	0.062	0.2	0.2	-0.1	0.303
Attitudes towards the farming practice									-0.2	-0.2	-0.1	0.312
Social norms									**0.6**	**0.5**	**0.5**	**0.026**
Sig.	0.848				0.103				**0.044**			
R2	0.042				0.349				0.583			
Adj. R2	-0.046				0.080				0.235			
F value	0.038				2.910				3.256			

Practical implications

The aims of this study were twofold:

1. Apply Theory of Planned Behaviour within one agronomist delivered practice change project.
2. Respond to recent calls for more consistent applications of theory in empirical research as a means of building reliable and valid knowledge to inform initiatives in sustainable farming.

Understanding the drivers of intentions to continue recommended farming practices

Theory offers a roadmap that when followed should achieve the intended outcomes (Rundle-Thiele et al. 2019). By understanding more about how people think and feel, psychosocial theories deliver explanations about why people behave the way they do. This paper demonstrates how psychological and social factors can be incorporated into evaluations to monitor and measure intentions to continue farming practices. A survey was administered by an extension service provider on behalf of the research team. The research team analysed data and provided a report to the project funder and the extension service team. This paper modelled the data to understand which Theory of Planned Behaviour constructs were influencing self-reported farming practice changes. Results demonstrate that social norms were the only factor within the broader Theory of Planned Behaviour explaining 23.5% of the variance in behaviour. In simple terms, this means that improving social norm perceptions will lead to continued application of the farming practice behaviour.

The path forward - Increasing farming practices to benefit the environment

The current study demonstrates the role social norms have on the adoption of agronomist recommended farming practices. In this study the desired farming practice behaviours were performed by growers when they felt other growers viewed the performance of this practice positively (see the social norm measure in Table 2). This statistically significant finding demonstrates that farmers can be influenced through social norms and approaches that emphasise others' perceptions will support farmers to continue the recommended farming practice. Norms messages can be developed from survey data insights. Examples would be '*XX% of sugar cane farmers apply the regulated amount of nitrogen to their farms'* or '*4 out of 5 sugar cane farmers have implemented a farm management plan*.'

The social norms item used in this study was singular and our understanding of social norms is more advanced. Social norms capture perceptions of what people think others are doing (descriptive norms) and perceptions of what people think others think they should do (injunctive norms). Inclusion of measures capturing the different types of social norms can further assist development of the farming practice change project. Further examples of the types of measures that can be used to capture the different types of social norms are identified in Table 4.

Table 4. Social norms measures

Measure	Scale Anchor
Injunctive norm measures	
People who are important to me think I should/should not [insert farming practice here].	Should not–should
People who are important to me would disapprove/approve of the [insert farming practice here].	Disapprove–approve
People who are important to me want me to [insert farming practice here].	Strongly disagree–Strongly agree
Descriptive norm measures	
Most growers I know [insert farming practice here].	Strongly disagree–Strongly agree
Most growers in {insert region here] [insert farming practice here].	Strongly disagree–Strongly agree

Source: Pang et al. (2017)

By understanding the influence of particular types of social norms (e.g. injunctive and descriptive) further guidance on communication actions can be gained. Measuring and monitoring descriptive and injunctive norms can provide insights to guide project management. For example, when perceptions of descriptive norms are lower than the proportions of people performing the practice, clear communication about the percentage of growers performing a behaviour will demonstrate what other growers are doing, potentially influencing individual growers' social norms. For lower perceptions of injunctive norms, communication demonstrating approval of other growers will also further increase social norms and in turn increase the desired farming practice behaviour. Supporting actions that increase social norms will support farming practice change ensuring outcomes such as improved water quality are realised benefitting the GBR.

Identification of theoretically derived mechanisms of action enables researchers to determine why some programs succeed and others fail. By applying theory, a roadmap can be identified delivering a fine-grained understanding of how the intervention is (or is not) supporting people to make the desired behavioural changes (Michie & Abraham 2004; Rothman 2004; 2009). By applying theories, such as the Theory of Planned Behaviour, primary industries and natural resource management practitioners can gain some understanding of the human dimension. In this study 23.5% of the variance in the adoption of recommended farming practices was explained by social norms. Other factors outlined in the Theory of Planned Behaviour did not explain adopted farming practices. The study sample size may have limited the explained variance and more research is recommended using larger sample sizes before definitive conclusions are drawn. Larger sample sizes will permit confidence in analytical methods applied in this paper and it will permit further analyses requiring much larger samples to be undertaken including mediation analysis and structural equation modelling. However, the findings in the present study are in line with meta-analytic studies identifying that on average TPB explains 27% of the behaviour studied (Armitage & Conner 2001).

A further limitation of the present study centres on the implementation approach applied. The research team prepared the survey and data was collected by stakeholders involved in the farming practice change project. This may have led to a biased outcome. Administration of the survey by the research team, who had no direct involvement in day-to-day program implementation, direct to growers that permitted anonymity would have minimised any bias in data. Further, implementation of longitudinal research designs would have permitted change to be modelled, extending understanding beyond self-reported current behavioural practices. The data collected in this study was limited to a survey. An ability to apply mixed methods would have extended understanding, providing insights into the failure of attitudes and perceived behavioural control to predict the farming practices that were self-reported in this study. Implementation of observational methods would permit farming practice behaviour to be monitored, extending data assessments beyond self-reports which are prone to social-desirability responding.

Understanding how people think and what people plan to do may help identify how to influence behaviour. The Theory of Planned Behaviour, is one of many theories outlining factors that can be included in evaluation studies to identify the influence that social and psychological factors may (or may not) exert a person's behaviour. When scientific enquiry is supplemented with social science approaches, we can understand more about how and why people act. Moving forward extension services, agronomy support services and natural resource management practitioners should monitor social and psychological factors to build then evidence base to understand more about how desired outcomes are realised. By monitoring social and psychological factors (intentions, perceived behavioural control, attitudes and social norms) and understanding the influence of these factors on farming practice behaviours (e.g. reduction of nitrogen application) practitioners can make program changes that are aimed at increasing the desired behaviour. Improvements in uptake of farming practice behaviours will contribute towards achieving the desired environmental outcomes (e.g. improved water quality).

Theory of Planned Behaviour has its critics (see David & Rundle-Thiele 2018, p. 184) and a considerable body of work has been undertaken on the theory. Applying theories that move focus beyond how an individual thinks and feels will further extend understanding. Calls have been made to challenge the research community to apply and test theories as reported in this paper and to commence work to build understanding of how behaviours can be maintained or changed. Models that consider whether people have the ability and social and environmental support to change do exist in the literature and future work applying other theories clearly and transparently is recommended to further inform practice. The more we can apply roadmaps that are known to work, the more success in program delivery can be guaranteed.

Summary and Conclusion

Psychological and social theories have been built describing why people perform (or not) focal behaviours. Application of theory is recommended but remains rare in practice. This study applied the Theory of Planned Behaviour to understand farming practices, specifically reductions in nitrogen application. The study identified that 23.5% of the variance in farming behaviours was explained by the Theory of Planned Behaviour. Hierarchical regression identified the influence of social norms on the adoption of the desired farming practice. One indicator was used in the current study to capture social norms. Further precision can be gained, and additional measures of social norms are provided for practitioner consideration. In future, measurement of psychological and social factors is recommended to extend understanding beyond what people are doing. Monitoring the factors known to influence behaviour will better enable and support practice change further supporting progress towards achieving water quality targets. By understanding what growers

think support service providers can fine tune communications to change grower perceptions in turn influencing farming behaviour.

Acknowledgements

Data collection was funded by Queensland Government. The preparation of this scientific paper was supported with funding from the Australian Government's National Environmental Science Program. The team thank staff at Department of Environment and Science and Department of Environment and Energy who provided feedback on the survey at the time it was prepared for the evaluation study. Our team wish to thank the Department of Environment and Science staff, the agronomy service provider team and the growers who assisted the data collection and granted us permission to use the data for this work. We wish to thank the growers who completed the survey. The funding bodies were not involved in the data preparation, data analysis, interpretation of data reported in this manuscript.

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