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Understanding the human dimensions of landholder innovation and stewardship

Identifying indicators of a culture of innovation and stewardship, and land management practice change

June 2018

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RP190 Stage 1 Milestone Report

Contents

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1 Executive Summary

This project proposes a set of indicators that may reflect a culture of innovation and environmental stewardship, and land management practice change in the agricultural sector.

These indicators may be used by the Queensland Government to provide a human dimensions baseline measure as articulated in the Reef 2050 Reef Water Quality Improvement Plan (RWQIP) – providing an assessment of progress towards adoption targets, and enabling an assessment of areas for improvement (which may inform program design and delivery).

The project involves 3 main stages:

1. A review of academic literature to conceptualise a model and propose a set of indicators. This step will address the question "What should we measure?"
2. A review of secondary data and reports to map and then synthesise existing data onto the proposed set of indicators. This step will address the questions "What do we already measure?" and "What does it tell us?"
3. Final set of recommendations proposed for deploying or improving a 'human dimensions' baseline measurement system. This step will address the question "How can we improve our measurement?" and "What do we need to keep measuring in future"?

The current report presents the results of the first stage, that is, the review of academic literature. This review involved:

- Reviewing conceptual models of culture, and of environmental stewardship to identify possible theoretical indicators,
- Reviewing empirical studies to identify indicators that have been shown to be (ideally causally-) related to, or important considerations in understanding, land management practice change, and
- Synthesising conceptual theory and empirical evidence to prioritise and present a small set of indicators or indicator themes that may be closely associated with a culture of innovation and environmental stewardship, and land management practice change.

Results revealed a number of variables that may be linked to a culture of innovation and environmental stewardship, and land management practice change – reflecting the internal, psychological make-up of farmers, their social environment, and the broader cultural milieu. However, there was no evidence to show that any of these variables causally influence land management practice change – we could only determine that certain variables were more or less strongly related to land management practice change.

Nonetheless, based on an assessment of their conceptual relevance and the available empirical evidence, a small set of indicator themes were selected. These are presented in Table 1.

The next stage of the project will involve an exploration of whether (and how) our selected indicators have been used in previous reef-related projects when engaging farmers on practice change. This step should provide confirmation of the practical relevance of our selected indicators and identify any gaps where additional indicators may be required.

Table 1. Preliminary set of indicator themes

INDICATOR THEME	DESCRIPTION	EXAMPLE QUESTIONS/MEASURES[1]
Attitudes (towards the practice)	How attractive, beneficial and/or risky the practice is (compared to current practice).	To what extent do you believe that [insert behaviour] is a risky thing to do? e.g., To what extent do you believe that [reducing the amount of nitrogen fertiliser you apply to your crop/using recycle pits/fallow management] is a risky thing to do?
Perceived behavioural control	How easy or difficult it is to perform the practice (self-efficacy/ capability), and whether it is within one's control (perceived control).	How easy or difficult would it be for you to [insert behaviour]? e.g., How easy or difficult would it be for you to [reduce the amount of nitrogen fertiliser you apply to your crop/use recycle pits/use fallow management] on your property?
Perceived barriers (control beliefs)	The extent to which one perceives that certain barriers are impeding performance of the practice.	To what extent do each of the following limit your ability to [insert behaviour]? e.g., To what extent do each of the following limit your ability to [reduce the amount of nitrogen fertiliser you apply to your crop/use recycle pits/use fallow management]? (e.g., time, cost, other).
Motivation	How motivated one is to perform the practice, and whether this is for intrinsic or extrinsic reasons.	Please tell us why it important to you to [insert behaviour]? e.g., Please select why it is important to you to [reduce the amount of nitrogen fertiliser you apply to your crop/use recycle pits/use fallow management]. Because… a. of the possibility of improved productivity (extrinsic) b. of the possibility of contributing to something worthwhile (intrinsic)
Behaviours (past and future)	Whether the practice (or precursor practices) has been used in the past, and whether there is a stated intention to trial or use certain practices in the future, in a particular situation, at a particular time.	In the past [insert timeframe], have you [insert behaviour]? e.g., In the past year, have you [reduced the amount of nitrogen fertiliser you apply to your crop/used recycle pits/used fallow management]?
Group norms	Whether other land managers/ farmers in the community (with whom one has strong ties) approve of, and perform the practice themselves.	What proportion of growers in your local area would think that [insert behaviour] is a good thing to do? e.g., What proportion of growers in your local area would think that [reducing the amount of nitrogen fertiliser you apply to your crop/using recycle pits/using fallow management] is a good thing to do?
Trust	Leve of trust in information sources and advice networks related to improved practices.	How much do you trust the advice you receive from [source] about [insert behaviour]? e.g., How much do you trust the advice you receive from industry experts about [reducing the amount of nitrogen fertiliser you apply to your crop/using recycle pits/using fallow management]?

[1] For any behaviour it is necessary to ask each indicator question (i.e., attitudes, perceived behavioural control, barriers, motivation, behaviours, group norms and trust) for that particular behaviour.

INDICATOR THEME	DESCRIPTION	EXAMPLE QUESTIONS/MEASURES[1]
Cultural norms	Community- and industry-level norms that encourage/facilitate innovation and stewardship practices.	Are farmers in your local area encouraged to work together to develop new ways of looking after the land? (see Appendix A.1 for other example questions)
Cultural artefacts	Community and industry level artefacts (stories, standards, codes, rituals and communications) that encourage innovation and stewardship practices.	How often do you attend field days where you can meet other farmers to discuss new farming practices? How clear do you find the codes and standards about good farming practices, which are promoted by the industry? (see Appendix A.1 for other example questions, including objective measures)

2 Project Background

To protect and improve water quality in the Great Barrier Reef catchment zone, the Queensland Government's draft Reef 2050 Water Quality Protection Plan (RWQIP) (The State of Queensland, 2017) has specified a target of 90% of sugarcane, horticulture, cropping and grazing lands to be managed using best management systems in priority areas.

Overall progress towards this 90% land-area target, as measured via the annual Great Barrier Reef Report Card, shows that it is insufficient, variable and slowing. In terms of population-wide practice change, only 4.60% of graziers (i.e., 394 of 8,545 graziers) and 16.68% of sugarcane growers (i.e., 630 of 3,777 sugarcane growers)[2] are engaged in industry best management practice programs. This low level of uptake suggests environmentally-friendly water quality farming practices are by no means standard practice among the farming community.

In an effort to meet the target, the RWQIP has specified an 'on-ground delivery action' of supporting both industries and communities to build a culture of innovation and stewardship (p. 20, p. 23-24)[3]. It is considered that a culture of innovation and stewardship is a necessary condition for the voluntary adoption of innovations, programs and practices (beyond minimum standards) that lead to continuous improvements in water quality.

Consistent with this notion, the RWQIP additionally states that a range of 'human dimensions' – factors existing at all social scales from the individual through to society-wide – play a role in shaping the social, economic, cultural and environmental outcomes associated with the Great Barrier Reef (p. 18). These human dimensions are new to the RWQIP, and are envisaged to be specified as actual quantitative target(s) in future plans.

[2] These percentages were calculated by taking the total number of graziers (n=8,545) and sugarcane growers (n=3,777) from the Great Barrier Reef Report Card 2016 and the number who have engaged in industry best management practice programs from the Report Card 2016 infographic (available at https://www.reefplan.qld.gov.au/measuring-success/report-cards/2016/).

[3] The other two on-ground delivery actions include (1) applying minimum practice standards across all industries and land uses, and (2) catchment restoration.

2.1 Objectives

The main objective of this report is to establish a set of indicators of culture and other human dimensions relevant to understanding landholder innovation and stewardship, and land management practice change. Specifically, we identify a set of indicators that may be used by Government to not only track changes over time in various 'human dimensions', but also to provide indications of likely future adoption of new innovations, programs and/or practices, and to even inform how such innovations, programs and/or practices are designed and delivered.

We proceeded by first considering conceptual frameworks on culture and environmental stewardship to identify possible indicator concepts. We then reviewed empirical studies with farmers in the Great Barrier Reef catchment zone, and drew on theory and evidence in other relevant domains, to shortlist a smaller number of indicator concepts for further exploration.

3 Frameworks for understanding a culture of innovation and stewardship, and land management practice change

There currently is no existing causal framework to explain how a culture of innovation and stewardship, and land management practices, may emerge. However, we can refer to existing conceptual frameworks of a culture of innovation, and of environmental stewardship, separately.

3.1 A culture of innovation and stewardship

It is useful to take a cultural perspective to defining innovation and stewardship as it helps recognise the influence of factors beyond the individual (e.g. the farm as a business, farmers and land managers as part of broader communities of practice and place, and operating within organised commodity groupings and supply relationships).

While numerous definitions exist, culture has been defined as 'a fuzzy set of basic assumptions and values, orientations to life, beliefs, policies, procedures and behavioural conventions that are shared by a group of people, and that influence (but do not determine) each member's behaviour and his/her interpretations of the 'meaning' of other people's behaviour' (Spencer-Oatey, 2008). In the organisational psychology domain, culture has received extensive attention and a multi-layered model of culture has been developed (Schein, 1992).

As shown in Figure 1 (and applied to innovation and stewardship in agriculture, for our purposes) this model proposes that organisational values are indirectly communicated through norms and artefacts, and observed in behavioural patterns. Values are underlying social principles and standards; norms are accepted, expected and encouraged behaviours that characterise routines and practices; and artefacts may include stories, physical arrangements, rituals and language.

This model has been successfully applied to understanding a culture of innovation in service firms (Hogan & Coote, 2014). We further propose that the model may be extended to create a model of a culture of innovation and stewardship in the agricultural sector. Note though that the measures underlying each of the sub-constructs (values, norms and artefacts) would require additional

research to formulate, given that the constructs are new to the context of agriculture[4]. Figure 1 simply provides some examples (see also Appendix A.1 for example indicators of norms and artefacts based on Hogan & Coote's (2014) survey). We also propose that since our ultimate goal is to define a parsimonious set of indicators, it may be wise to focus on the more proximal influences of norms and artefacts, and to disregard the distal factor of values.

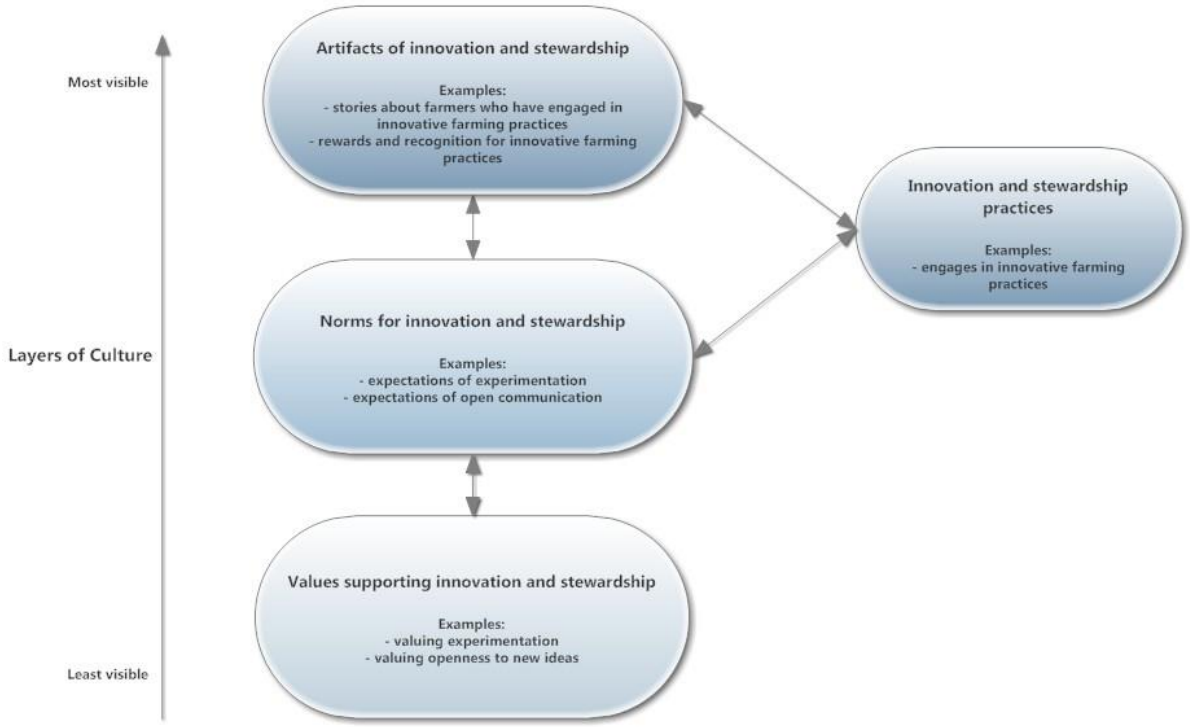

Figure 1. A culture that supports innovation and stewardship
Source: Adapted from Hogan & Coote (2014)

3.2 Environmental Stewardship

In an effort to synthesise the literature and guide future research on stewardship, a comprehensive, integrative framework of environmental stewardship has recently been developed[5] (Bennett, Whitty, Finkbeiner, Pittman, Bassett, Gelcich & Allison, 2018) (see Figure 2). The overarching premise of this framework is that stewardship (as the 'actions') depends on the actors in the system, and whether those actors have both the capacity and motivation to act. These facets are influenced by the broader social-ecological context. As shown in Figure 2, a number of resources or 'local assets' and institutions are proposed to provide the capacity to act; and motivational drivers may be separated into intrinsic versus extrinsic factors.

[4] Such research may involve interviews with farmers and stakeholders to better understand the features of an ideal or desired culture of innovation and stewardship in the farming arena (i.e., What would a culture of innovation and stewardship look like to you?).

[5] The following definition for environmental stewardship was proposed by these authors: 'local environmental stewardship is the actions taken by individuals, groups or networks of actors, with various motivations and levels of capacity, to protect, care for or responsibly use the environment in pursuit of environmental and/or social outcomes in diverse social-ecological contexts.'

This framework is instructive for our purposes of identifying additional human dimensions, beyond culture, that may be included as indicators of land management practice change[6]. For instance, it would appear important to include variables that measure landholders' personal motivation to engage in stewardship practices, as well as social capital (the informal and formal relationships, which facilitate trust and reciprocity to support stewardship) and human capital (the individual and group attributes such as knowledge, awareness, skills that enable stewardship). To assist us in identifying what human dimensions to specifically include in this regard, we can refer to previous empirical research and theory.

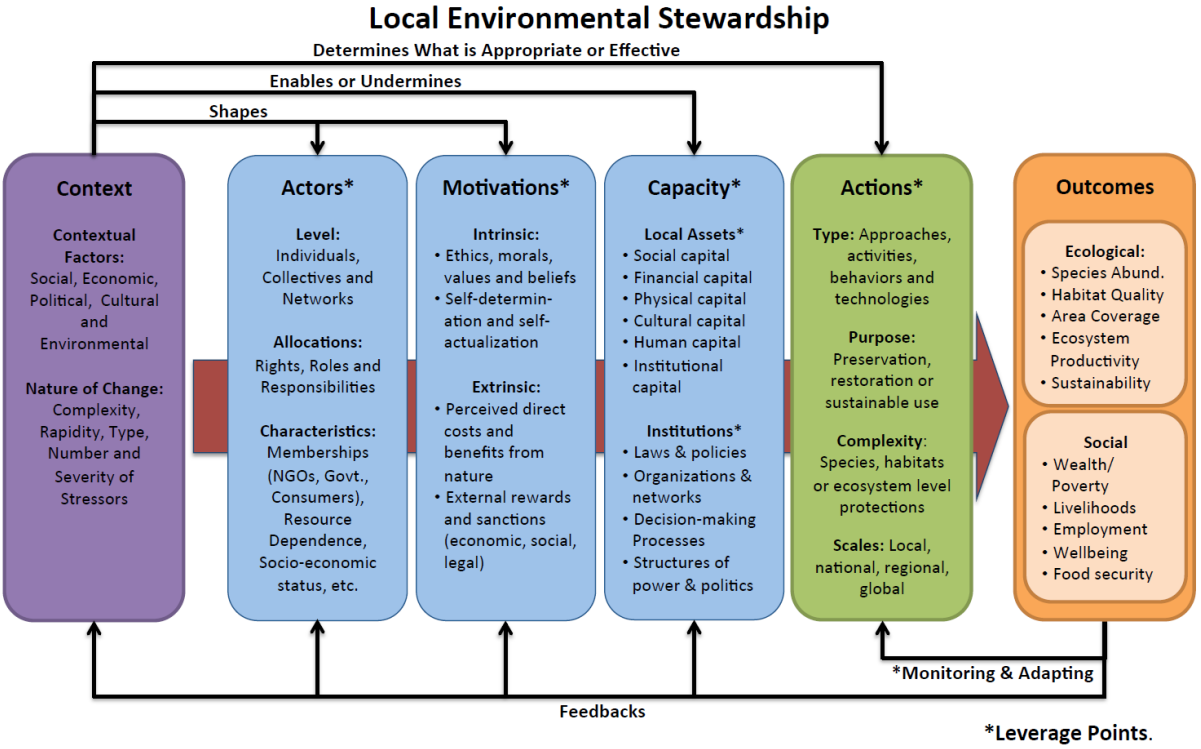

Figure 2. Analytical framework for the elements of local environmental stewardship.

Source: Reproduced with permission from the first author of Bennett et al. (2018). See http://creativecommons.org/licenses/by/4.0/

4 Assessment of Indicators

Of most relevance to our selection of indicators is empirical evidence from studies conducted with farmers in the Great Barrier Reef catchment zone. It became apparent from a review of these studies that a host of individual and social factors may be proposed to play a part in the adoption of new farming practices (see Appendix A.2 for a summary of the results of these studies), but very little could be said about whether such factors are causally linked to adoption[7]. We highlight this because one of the expected practical uses of the indicators is to predict future adoption.

[6] A culture of innovation and stewardship may simply be represented in this model as a 'contextual factors' component that enables the development of 'cultural capital'.

[7] The research conducted thus far has involved surveying or questioning farmers about their attitudes, perceptions, motivations, beliefs, needs, goals, behavioural intentions and/or current behaviour. But the only sure way to determine causation is to conduct a randomised controlled trial where some hypothesised variable of influence is systematically manipulated, and the impacts on actual farming practices are measured. Of course, this can be difficult to accomplish with a highly heterogeneous population, small samples, close-knit communities (where the possibility of spillover – the risk of interference between conditions – is high) and limited resources. So it is understandable that such experimental research has not yet

Despite the lack of evidence of causality, our selection of indicators can certainly still be guided by the strength of the association (in quantitative work) and frequency/intensity of mentions (in qualitative work). Additionally, to provide a more comprehensive and robust assessment, we referred to international studies with farmers, as well as the broader literature on behaviour change. The details of our assessment exercise are provided in Table 2. For each of the indicators that were considered, we provide a conceptual argument and supporting empirical evidence to guide its selection or not. We also provide an overall assessment of suitability.

been performed in the Great Barrier Reef catchment zone. All this means is, of the factors examined in prior research on farmers in the Great Barrier Reef, we cannot truly know which factors (if any) will unquestionably predict adoption.

Table 2. The Assessment of Indicators

Construct and sample questions	Theoretical or conceptual argument	Empirical evidence in agricultural farming practices
Internal factors		
Values: Goals for property management Overall assessment of suitability: Relatively weak Conceptual validity: Poor (more distal, weaker influence) Empirical evidence: Poor (farmers can hold multiple goals; different goals associated with same behaviour)	Raising awareness of current behaviour and its problematic consequences for water quality and the reef, and encouraging farmers to feel a sense of responsibility, have been discussed as a necessary first step in the adoption process (Pannell, Marshall, Barr, Curtis, Vanclay & Wilkinson, 2006; Blackstock, Ingram, Burton, Brown & Slee, 2010). Additionally, the underlying property management goals or values of landholders is presumed to influence the importance or level of concern that they have for various issues relating to land management (Emtage & Herbohn, 2012a, 2012b). These concepts are consistent with numerous behavioural theories that have been developed to explain pro-environmental behaviour (e.g., Value-Belief-Norm theory: Stern, 2000; Norm-Activation Model: Schwartz, 1977; the Theory of Planned Behaviour: Ajzen, 1991). Basically, these theories posit a causal and interactive chain of influence among many internal and external variables. More generalised internal factors (e.g., values and beliefs) are considered distal and weaker in their effects (as well as more difficult to change), whereas more targeted internal and external factors (e.g., personal and group norms, perceived behavioural control, attitudes, situational factors and intentions) are considered proximal to, and stronger influences on the behaviour itself (and relatively easier to modify). The terms 'value-action gap' and 'knowledge-action gap' have been coined in the pro-environmental behaviour domain to represent the fact that there is often a significant gap between what people value, know or are aware of, and what they do (Kollmuss & Agyeman, 2002). Additionally, while personal norms are hypothesised to have a more proximal impact on behaviour, research in the pro-social behaviour domain indicates that they need to be made salient or focal (in the situation itself) to have an effect (Kallgren, Reno & Cialdini, 2000, Study 3). Ultimately, it is a mistake to assume that once people know what they should do and why they should do it, that they will then proceed to do it. We would suggest that although one's values, awareness, knowledge and sense of culpability may be associated with behaviour, they may not be particularly strong indicators – and certainly not as strong as variables that are more explicitly tied to the behaviour in question (as was observed in a meta-analysis of best management practices adoption in the U.S., by Baumgart-Getz, Prokopy & Floress, 2012).	A survey of rural landholders in the wet tropics NRM catchment of Far North Queensland suggests that farmers (61% of whom listed agriculture as the primary purpose of land ownership) may adopt farming practices that are consistent with their general land management goals, but this relationship is also likely to be heavily influenced by external factors (Emtage & Herbohn, 2012b). Farmers who reported highest scores on the goal of 'improving the environment' had the highest adoption of Best Management Practices relating to vegetation management. However, farmers who were production oriented (with low importance placed on environmental issues) still had high rates of adoption of Best Management Practices and participation in government programs. This was explained by the fact that production-oriented farmers tended to have larger properties, and may therefore have had more capacity/staff to adopt new processes, and participate in programs. To determine the true impact of goals on behaviour requires these extraneous, confounding factors to be controlled. Other research indicates that farmers can hold multiple goals including both environmental- and production-based goals (e.g., 'building a business', 'improving the natural environment' and 'keeping the property in the family and lifestyle maintenance' were all rated highly by landholders: Emtage & Herbohn, 2012a; and graziers in the Burdekin stated that they had adopted riparian management practices for both production and environmental reasons: Lankester, Valentine & Cottrell, 2009). There also is some indication that the vast majority of growers weight economic-related goals as the highest priority (among sugarcane growers in the Wet Tropics, Burdekin and Mackay Whitsundays catchments, most were focussed on maximising production and profit: Rolfe & Harvey, 2017), and these growers also showed a greater propensity to perform some of the better BMPs (though we note that the authors applied a lenient significance level of p=0.20). A study with graziers in the Burdekin revealed that farmers with high conservation and lifestyle motivations had higher adoption rates of conservation practices (Greiner, Patterson & Miller, 2009). However, another study with graziers in that catchment revealed that although they had a very high level of conservation and lifestyle motivation (and were motivated to a lesser extent by financial/economic or social considerations) overall, they still rated income tax incentives, cost-sharing for individual conservation projects and increased public acknowledgement of environmental achievements as effective policies in overcoming barriers to the adoption of conservation practices (Greiner & Gregg, 2011). This suggests that one may hold conservation goals but still be motivated by other factors – though this remains to be empirically tested. Qualitative research indicates that farmers in the Great Barrier Reef catchment may be sceptical of the problem and the role they play in it (e.g., beef graziers: Lankester et al., 2009 and sugarcane farmers: Benn, Elder, Jakku & Thorburn, 2010). Relatedly, a more recent survey with canegrowers has also shown that farmers feel less personally responsible for water quality problems, as compared to their ratings that this responsibility lies with the cane industry overall or other industries (Pickering, Hong, Stower, Hong & Kealley, in press). Additionally, a survey with farmers in the U.S. has revealed that awareness of the negative consequences of various farming outputs (fertilizer, manure, pesticides, and soil erosion) on water quality, and stewardship attitudes (a combination measure of ascription of responsibility, personal norms and community benefits of clean water) were both positively associated with willingness to take action to improve water quality (β=0.10, $p<0.05$ and β=0.67, $p<0.0001$, respectively) (Floress, de Jalon, Church, Babin, Ulrich-Schad & Prokopy, 2017). Stewardship attitudes mediated the impact of awareness on willingness, suggesting that stewardship attitudes may have a more proximal and stronger impact on behaviour, whereas awareness is more distal and weaker in its effects. This is consistent with prior meta-analytic research on farmer conservation behaviour revealing that general awareness is a weak predictor of behaviour (Baumgart-Getz et al., 2012; Prokopy, Floress, Klotthor-Weinkauf & Baumgart-Getz, 2008). It is better to measure awareness of specific actions (e.g., awareness of how the actions of farmers' impact on water quality, and understanding the goals and activities of BMP were significant correlates of BMP adoption: Baumgart-Getz et al., 2012).
Beliefs: Awareness of problem /consequences Overall assessment of suitability: Relatively weak Conceptual validity: Poor (more distal influence) Empirical evidence: Lacking (limited results)		
Beliefs: Ascription of responsibility Overall assessment of suitability: Relatively weak Conceptual validity: Poor (more distal influence) Empirical evidence: Lacking (no clear results available)		
Norms: Personal norms Overall assessment of suitability: Relatively weak Conceptual validity: Moderate (is more proximal, but may be a situation-specific influence) Empirical evidence: Lacking (no clear results available)		

Construct and sample questions	Theoretical or conceptual argument	Empirical evidence in agricultural farming practices
Attitude towards the practice (Relative advantage/ Perceived costs/risks vs. benefits) Overall assessment of suitability: Moderate Conceptual validity: Moderate-strong (is more proximal, and needs to be practice-specific) Empirical evidence: Moderate-strong	It has been discussed that actual adoption substantively relies on whether the new practice/innovation is clearly beneficial to the farmer and offers advantages over their current practices (consistent with the characteristic of a practice, known as 'relative advantage': Rogers, 1962; Pannell et al., 2006). The implication is that the practice should be designed to be as attractive to, and beneficial for farmers. Creating a practice that offers a number of clear advantages (annual benefit outweighs up-front cost, practice adoption can be reversed, number of years of profitability, short time for profit to be realised, environmental benefits, offers easy and convenient farm management) will likely lead to high population uptake in a shorter window of time (Kuehne, Llewellyn, Pannell, Wilkinson, Dolling, Ouzman & Ewing, 2017). At the individual level, many behavioural models include an assessment of attitudes (positive or negative evaluation), and/or of the benefits and costs (a cognitive judgement) associated with the behaviour. For example, the Theory of Planned Behaviour posits that beliefs and evaluations about the outcomes of the behaviour (e.g., likelihood of benefits and costs; valence of impacts) are important determinants of attitudes, which in turn (and along with perceived behavioural control and subjective norms), determine behavioural intentions. And in the technology adoption literature, an assessment of the magnitude of the risks and benefits is posited to affect overall acceptance (e.g., Terwel, Harink, Ellemers & Daamen, 2009). For landholders assessing the costs and benefits of adopting new practices, it is also worth noting a number of behavioural anomalies that may be expressed in this context. First, in what is known as future or temporal discounting (Frederick, Loewenstein & O'Donoghue, 2002) and loss aversion (Kahneman, Knetsch & Thaler, 1991) – we propose that farmers may be very short-sighted, focussing on the immediate costs/risks of new farming practices (financial cost, time/labour requirements), and discounting any future benefits (reducing erosion, protecting water quality). Additionally, the benefits of new practices may be seen as largely benefiting the public rather than their private selves. Further compounding this – for sugarcane growers – is the risk of loss of income (via reduced yield from reducing fertilizer usage). In this situation, consistent with the phenomenon of risk aversion (Kahneman & Tversky, 1979), farmers may be highly motivated to avoid risking loss of income, especially in the context of the competing high-probability prospect of more income (via increased yield from maintaining or even increasing fertilizer usage). While empirical evidence indicates that attitudes may be significantly associated with behaviour, we note that the relationship is not especially strong. This is consistent with the broader pro-environmental behaviour literature, which reveals a discrepancy between attitudes and behaviour known as the 'attitude-behaviour gap' (Kollmuss & Agyeman, 2002). This discrepancy is most marked when the attitudinal assessment is global in nature (e.g., pro-environmental attitudes versus attitudes towards the practice itself). Furthermore, it is also argued that social and cultural influences propagate pro-environmental behaviours, irrespective of the attitudes that individuals hold (Kollmuss & Agyeman, 2002).	Qualitative research with sugarcane growers indicates that reduced nitrogen application may be seen as an uncertain, risky and costly activity – with farmers wanting to see the results of reduced nitrogen application over many years and under a variety of environmental conditions (Benn et al., 2010). The benefits to the reef may also be seen as uncertain, future-focussed, spatially-distant and shared by others (therefore they may be classified as a public good not a benefit to the farmer per se). Whereas the costs may be quite salient and immediate for the farmer. This suggests that sugarcane growers may not perceive the practice as particularly beneficial or favourable. A survey of graziers also revealed that farmers who perceived the benefits as more likely and favourable, held stronger intentions to manage their riparian zones (Fielding, Terry, Masser, Bordia & Hogg, 2005). They also rated all the costs as significantly less negatively. Consistent with the view that farmers may not perceive that the benefits as outweighing the costs, inspection of the mean scores for benefits and costs across the entire sample showed that the benefits tended to be rated as less likely than the costs to occur. Additionally, over the entire sample, the average valence rating for costs was more extreme on the scale, than was the valence rating for benefits. In another two studies, landholders with more positive attitudes (which included an assessment of how beneficial the practice was) towards the practice at Time 1 also had stronger intentions to manage their riparian zones at Time 2 (β=0.16 in Study 1, $p<0.001$; β=0.21 in Study 2, $p<0.001$: Fielding, Terry, Masser & Hogg, 2008). A survey of farmers in the U.S. revealed that stewardship attitudes (a combination measure of ascription of responsibility, personal norms and community benefits of clean water) was positively associated with willingness to take action to improve water quality (β=0.67, $p<0.0001$) (Floress et al., 2017). Though we critique this measure of stewardship attitudes as it did not measure attitudes towards environmentally-friendly farming practices per se, but rather it assessed underlying beliefs and personal norms regarding water quality. Similarly, a qualitative study with (mainly crop) farmers in Indiana, found that perceived high levels of relative advantage (along with its compatibility with farm system and needs of producer) and observability (i.e., observing these advantages) were the most important reasons for adopting conservation practices (Reimer, Weinkauf & Prokopy, 2012). Perceived risk and complexity on the other hand, where mentioned as key factors that limited the adoption of a few practices.
Perceived behavioural control (self-efficacy, perceived control) Overall assessment of suitability: Relatively strong Conceptual validity: Strong Empirical evidence: Moderate	Perceived behavioural control – the extent to which people believe that the behaviour is within their control (perceived controllability), and capabilities (self-efficacy) – is a key factor in the Theory of Planned Behaviour (Ajzen, 1991), and a central tenet of behavioural economics (in terms of making things as easy as possible for people to perform). Perceived behavioural control is considered a superordinate construct comprised of both perceived controllability (the extent to which performing the behaviour is up to the person) and perceived self-efficacy (confidence in performing the behaviour; ease or difficulty of performing the behaviour) (Ajzen, 2002). Perceived behavioural control may also relate to whether people are even willing to try out the new practice (as per the characteristics of a practice in terms of perceived complexity and trialability: Rogers, 1962). The implication is that the practice should be designed from the outset to be easy for farmers to perform so that they can learn about the practice and its outcomes. This learning aspect is expected to influence how quickly a population of farmers come to adopt a new practice (Kuehne et al., 2017).	Perceived behavioural control has been shown to be a positive correlate of intentions in the agricultural context: Landholders with a greater sense of control had stronger intentions to manage their riparian zones (β=0.31 in Study 1 and β=0.27 in Study 2, $p<0.001$) (Fielding et al., 2008). Perceived behavioural control had the strongest association of all variables studied, with the exception of past behaviour.

Construct and sample questions	Theoretical or conceptual argument	Empirical evidence in agricultural farming practices
Perceived barriers (control beliefs) Overall assessment of suitability: Relatively strong Conceptual validity: Strong Empirical evidence: Moderate	One of the ways of measuring perceived behavioural control is to measure beliefs about one's ability to deal with specific barriers, as well as facilitating factors (Azjen, 2002). In contrast to more global measure of perceived behavioural control, belief-based measures of perceived behavioural control provide insight into the particular factors that may contribute to the overall assessment of perceived behavioural control. Knowing the exact factors that may be hindering or facilitating performance of the practice is informative for program design. As articulated within the Theory of Planned Behaviour, these beliefs are known as 'control beliefs'. And control beliefs are the beliefs that people hold regarding the extent to which a set of potential barriers prevents them from taking the desired action (for an example in the context of riparian management, see Fielding & Hogg, 2005). Thus, it may be important to include a set of further questions measuring control beliefs, to ascertain what factors in particular may be acting as barriers and contributing to the more global assessment of perceived behavioural control.	In a further study, graziers with strong intentions to manage their riparian zones held a greater belief that identified barriers (with the exception of lack of money) could be overcome, than did graziers with weak intentions ($p<0.001$) (Fielding et al., 2005). Financial factors (high costs for capital investment and cash flow, high fixed costs) have been identified as a significant barrier to the adoption of BMPs among sugarcane growers (Rolfe & Harvey, 2017). This research also revealed a set of other variables (e.g., uncertainty in markets, and future climate; the need for new skills and information, and 'not easy to trial') as significant barriers too. Further analysis revealed that growers who rated uncertainties as a significant barrier were less likely to perform certain BMPs (though we note that the authors applied a lenient significance level of p=0.20). The qualitative literature indicates that farmers may be willing to try new practices, but there are significant costs that may be making it difficult for farmers to do so. For example, some farmers simply do not have the funds to share the costs involved in participating in Reef Rescue (Taylor & Van Grieken, 2015). Government-funded, group-based commercial trials have been discussed by farmers as a way to reduce the costs, and inequity associated with individual farmers conducting separate trials (Taylor & Van Grieken, 2015).
Motivation: Intrinsic versus extrinsic motivation /Relative importance Overall assessment of suitability: Relatively strong Conceptual validity: Strong Empirical evidence: Lacking (no clear results available)	Bennett and colleagues' (2018) environmental stewardship model proposes that motivation is an essential component of environmental stewardship, as it elucidates the reasons that drive farmers to engage in environmentally-friendly practices. While prior research has explored general land management goals (as detailed above), we concur with Bennett and colleagues to suggest that it may be more instructive to assess intrinsic versus extrinsic motivations as articulated in the theory of self-determination (Deci & Ryan, 2000; Ryan & Deci, 2000) – which has been successfully applied to better understand pro-environmental behaviour (De Young, 2000; Grant, 2008; Tabernero & Hernandez, 2011). Intrinsic motivation can be defined as the desire to expend effort based on interest in, and enjoyment of the task itself (and the satisfaction of basic psychological needs for autonomy, belongingness/relatedness and competence); whereas extrinsic motivation is the desire to expend effort to obtain outcomes external to the task, such as reward or recognition (Grant, 2008). Intrinsic motivation has been found to be significantly positively related to pro-social (Grant, 2008) and pro-environmental behaviour (Tabernero & Hernandez, 2011), and is considered to be a long-term, durable motivator. Intrinsic motivation can be contrasted against extrinsic motivation, which is fundamentally and severely limited by its short-lived effects (i.e., once an extrinsic incentive disappears, so does the positive impact on behaviour) and undermining effects on intrinsic motivation (van der Linden, 2015). The intrinsic vs extrinsic dimensions of motivation are informative as they reflect the underlying motives or reasons for behaviour – information which can direct intervention efforts. However, there may be alternative, simpler ways of assessing overall motivation. For example, recognising that a farmer has many competing priorities and responsibilities, an alternative or additional way of measuring motivation to engage in a certain practice, may be to simply assess how important the practice is compared to other issues – that is, its relative importance. To the best of our knowledge, this construct has not received any empirical attention. However, it is consistent with goal-setting theory (Locke & Latham, 2002), which explains that people will commit to a goal if they believe that the outcomes of attaining the goal are important or significant (the other factor that enhances goal commitment is self-efficacy, which was discussed earlier within the construct of perceived behavioural control).	A survey with canegrowers in Queensland revealed that intrinsic motivation (the importance given to the following to the future: their family, family's long-term survival, their children's or grandchildren's future, the GBR, and advances in scientific understanding) was not correlated with BMP accreditation or other innovation-related variables (Pickering et al., in press). While complete details of how the question was asked are lacking, it appears that participants simply provided a general assessment of these intrinsic motivators (not specifically in terms of the importance of these reasons for engaging in environmentally-friendly practices).
Behaviour (prior and future) Overall assessment of suitability: Relatively strong Conceptual validity: Strong Empirical evidence: Moderate	An often-cited truism is that past behaviour is the best predictor of future behaviour, but this appears to only hold true when the behaviour is one that is highly repetitive and linked to a stable context (thereby facilitating the formation of habit: Oullette & Wood, 1998). In other behavioural domains – where conscious deliberation and decision-making is required because of changing or difficult contexts – then past behaviour may be considered a relatively weak predictor of future behaviour. Instead, in these circumstances, it has been proposed that behavioural intentions is a preferred indicator (Oullette & Wood, 1998). Intention to perform the behaviour is considered a strong predictor of actual behaviour as it is meant to index a person's motivation to perform the behaviour. However, there is still likely to be a marked gap between intentions and behaviour (known as the 'intention-action' gap) (Sheeran & Abraham, 2003; Sheeran, 2002). A meta-analysis of environmental behaviour studies found that intention explains about 27% of the variance in environmental behaviours (Bamberg & Moser, 2007). And a meta-analysis of experimental	Among all variables measured (as per the Theory of Planned Behaviour and Social Identity Theory), past behaviour has been shown to be the strongest correlate of behavioural intentions (Fielding et al., 2005, 2008). Though the relationship with self-reported behaviour was not significant in these studies. However, behavioural intentions were strongly associated with self-reported behaviour among both graziers and horticulturalists (Fielding et al., 2008). That is, intention to manage riparian zones (over the next 6 months) at Time 1 was positively associated with self-reported behaviour (over the past 6 months) at Time 2 (β=0.37 in Study 1, $p<0.05$; β=0.39 in Study 2, $p<0.05$) (Fielding et al., 2008).

Construct and sample questions	Theoretical or conceptual argument	Empirical evidence in agricultural farming practices
	studies has shown that a medium to large change in intention leads to a small to medium change in behaviour (Webb & Sheeran, 2006). External factors are considered critical in facilitating the enactment of intentions (Sheeran, 2002), especially if the behaviour is costly and requires significant changes (Herberlein, 2012). But it is also the case that intentions should be measured in a specific and implementation-focussed way (e.g., 'I intend to do X, in situation Y': Sheeran, 2002). Implementation intentions differ from behavioural intentions in that they specify the situation in which the practice/behaviour is intended to be performed. It is possible that this alternative intention construct will have greater predictive validity.	
External factors		
Group norms & identity Overall assessment of suitability: Relatively strong Conceptual validity: Strong Empirical evidence: Strong	There exists a wealth of evidence (including from experimental studies) to show that people are strongly influenced by what other people do and expect (otherwise known as descriptive norms and injunctive norms, respectively) (Cialdini & Trost, 1998). These types of norms provide people with guidance on what is considered normal and desirable behaviour, and it is the norms of behaviourally-relevant reference groups for which one feels strong ties (such as friends, family, and in our case, other landholders) that are considered to have the strongest influence on behaviour (even when compared to experts who may be better informed). Information about what other farmers are doing also may serve another function in communicating the degree of co-cooperativeness in the local community. As discussed above, given the situation may be considered a public goods dilemma where farmers are invariably investing in farming practices to improve water quality for all/the greater good, there is a possibility that some farmers may fail to participate. In this situation, positive group norms may provide the impetus to co-operate; whereas negative group norms would reinforce failure to take action. Similar to that of personal norms, it may be important to prime social norms to make them focal and impactful on behaviour (Kallgren, et al., Study 1 and 2). This has implications for the design of interventions and fostering a culture of innovation and stewardship.	Landholders who perceived that other rural/regional landholders in their community were more approving of (injunctive norms) and more likely to engage in (descriptive norms) riparian zone management, were more likely to intend to engage in riparian zone management themselves (β=0.18 in Study 1, $p<0.001$; β=0.21 in Study 2, $p<0.001$). This relationship emerged as significant only for those who were strongly identified with their rural/regional landholder community group (Study 2, $p<0.05$) (Fielding et al., 2008). Growers discussed the undesirability of working differently from others in their district (or their co-operative harvesting group consisting of several growers) (Taylor & Van Grieken, 2015). Graziers with strong intentions to manage their riparian zones were more willing to comply with referents, than were graziers with weak intentions ($p<0.001$) (Fielding et al., 2005). A survey with canegrowers in Queensland revealed that feeling a part of a community of canegrowers (as an indicator of group identity) was positively associated with a desire to improve farming practices: Pickering et al., in press). A survey with canegrowers in Queensland who had just viewed video clips of farmers' demonstrating new technology and practices revealed that farmers' decisions to adopt innovations was significantly influenced by peer norms (Thomas, 2011). Qualitative research with farmers in Iowa revealed that some farmers were reluctant to engage in practices that did not meet the informal local crop standards (McGuire, Mortin & Cast, 2013). Being branded 'polluters' triggered a movement to change locally accepted rules/norms for good farm management. Another (survey-based) study in France found that providing farmers with information about the intentions of other farmers (the social norm) significantly influenced a farmer's own decision about whether or not to continue certain environmentally-friendly farming practices (Kuhfuss, Pre'get, Thoyer, Hanley, Le Coent & De' sole', 2015). 61% of farmers stated that they would continue with these practices when provided social normative information, compared with 43% in the control group. Qualitative research with farmers in the UK also highlighted the importance of social influences, with farmers more likely to feel obligated to undertake environmental management practices, partly to maintain a positive social image (Mills, Gaskell, Ingram, Dwyer, Reed & Short, 2017).
Trust Overall assessment of suitability: Relatively strong Conceptual validity: Strong Empirical evidence: Moderate	There exists evidence (including from experimental studies) to show that people's trust in organisations (or entities associated with a product/service) affects their perceptions of the risks and benefits, which in turn affects their decisions (to accept new/risky technologies, for example: Siegrist, 1999, 2000; Terwel, et al., 2009). In this way, trust functions as a decision-making short-cut or heuristic – circumventing the need to engage in intensive cognitive processing. Given the scepticism, and perceptions of uncertainty, complexity and risk that may exist among farmers (with respect to reducing fertilizer usage for sugarcane farmers, but also actions to circumvent sediment loss for graziers), we can posit that trust may play an important role in farmers' decision-making in this particular context.	Qualitative research with sugarcane growers has identified the importance of local relationships between farmers and extension officers, to establish trust – especially during a situation where farmers were concerned about environmental regulations (Taylor & Van Grieken, 2015). Adviser credibility and trust has been discussed as an important element of extension (Emtage & Herbohn, 2012a, 2012b; Pannell et al., 2006), with results suggesting that productivity groups and neighbours/other farmers are more trusted than government and environment groups (Emtage & Herbohn, 2012a, 2012b; Pickering et al., in press). Permanent, locally-based, experienced people who know local conditions may be considered the most appropriate and trusted source of information and support. It is noted that the need for these advisers to support farmers in making changes for the public good (rather than their own personal goals) may transform the dynamic of the relationship and as such, requires more recognition and careful consideration (Pannell et al., 2006).

Construct and sample questions	Theoretical or conceptual argument	Empirical evidence in agricultural farming practices
Culture: Community or industry-level norms supporting innovation and stewardship practices Overall assessment of suitability: Relatively strong Conceptual validity: Strong Empirical evidence: Moderate	The literature has discussed the importance of farming subcultures (collective norms and practices) that exist within farming communities, and how a culture where farmers are enabled to develop or demonstrate skilled role performance (rather than the conventional means of simply following prescribed practices) can foster embodied cultural capital (Burton, Kuczera & Schwarz, 2008; Taylor & Van Grieken, 2015; Vanclay & Lawrence, 1995). This concept may reflect the contextual (cultural) factors that enable the development of 'cultural capital' as described in the environmental stewardship framework (Bennett et al., 2018). Group sharing of information and best practice among peers also may establish new group norms (Mills et al., 2017). We note that the norms specified in our model are not explicit farming practice norms per se (as in, 'farmers in our community are engaging in practice xyz'), but rather the injunctive norms associated with behaviours that supports innovative farming practices (as in, 'farmers in our community are encouraged to work together to develop new ways of looking after the land'). This is consistent with the human development approach – which emphasises the need for people to develop their own solutions to problems and the importance of social networks and interaction (Blackstock et al., 2010). By faciliating the involvement of farmers in the development of innovative new practices (rather than prescribing these), embodied cultural capital may be fostered in the farming community (Burton et al., 2008) and local knowledge can be better utilised (Pannell et al., 2006). Additionally, given that the issue of water quality is a public good problem requiring the participation of many people, it is critical that landholders can see that others in the community are participating in the effort.	Qualitative research with graziers revealed that social interactions with other producers and extension officers, particularly where practical learning occurred, were cited as strong influences on riparian management decisions (Lankester et al., 2009). Similarly, sugarcane growers have emphasised the importance of local advice and support networks in participating in the Reef Rescue scheme (Taylor & Van Grieken, 2015). In terms of ideas for the future, government-funded commercial, group-based trials (administered by regional bodies) of new practices also was discussed by these growers, with extension officers supporting this approach too, as a way to build a peer-to-peer based learning culture (Taylor & Van Grieken, 2015). Qualitative research with farmers in Iowa revealed that some farmers (with strong productivist identities) listened to, and learned from peers (with strong conservation identities), and gained confidence to try new practices on their own farms (McGuire et al., 2013). Even the sceptical farmers were interested in knowing the results of tests. The support of other farmers, and connection to a group appeared to motivate farmers to make changes.
Culture: Community-and industry level artefacts supporting innovation and stewardship practices Overall assessment of suitability: Relatively strong Conceptual validity: Strong Empirical evidence: Moderate	While industry may profess to value innovation and stewardship, and prescribe (expect) certain behaviours of farmers, such innovative and stewardship behaviours are unlikely to occur unless there are observable, manifest/demonstrable symbols/artifacts to support and reinforce the culture of innovation and stewardship (Hogan & Coote, 2014). This may include the provision of regular field days for farmers to demonstrate new practices and discuss ideas; and public awards for farmers who are demonstrating best practices (among other things, as shown in Appendix A.1).	Qualitative research revealed that some sugarcane farmers were disappointed by the fact that grant payments do not reward farmers who are already performing the new practice or using advanced technologies (Taylor & Van Grieken, 2015). A survey of graziers in the Burdekin revealed that increased public acknowledgement of environmental achievements by graziers would be an effective policy in overcoming the barriers to the adoption of conservation practices (Greiner & Gregg, 2011). A survey of canegrowers in Queensland revealed that a desire for cane growers to be better recognised, and perceptions of government support were positively correlated with BMP accreditation ($p<0.05$: Pickering et al., in press). A survey of farmers in France revealed that farmers who experienced social acknowledgement for their contribution to the protection of natural resources, were more likely to continue environmentally-friendly farming practices (even in the absence of payments) (Kuhfuss et al., 2015).

5 Proposed Indicators

Ultimately, our assessment exercise resulted in the selection of a small set of indicator themes that may characterise a culture of innovation and stewardship, and landholder management practices (see Table 1, repeated below).

Table 1. Proposed indicator themes and example questions

INDICATOR THEME	DESCRIPTION	EXAMPLE QUESTIONS/MEASURES[8]
Attitudes (towards the practice)	How attractive, beneficial and/or risky the practice is (relative to current practice).	• To what extent do you believe that reducing the amount of nitrogen fertilizer you apply to your crop, will lead to better outcomes for your farm? • To what extent do you believe that reducing the amount of nitrogen fertilizer you apply to your crop, is a risky thing to do?
Perceived behavioural control	How easy or difficult it is to perform the practice (self-efficacy/capability), and whether it is within one's control (perceived control).	• If you wanted to, how easy would it be for you to reduce the amount of nitrogen fertilizer you apply to your crops? • How confident are you in your ability to reduce the amount of nitrogen fertilizer that you apply to your crops? • Whether or not you reduce the amount of nitrogen fertilizer is a decision that is completely up to you.
Perceived barriers (control beliefs)	The extent to which one perceives that certain barriers are impeding performance of the practice.	• To what extent do each of the following prevent you from reducing the amount of nitrogen fertilizer you apply to your crops? (e.g. lack of time, difficulty in calculating fertilizer requirements, cost of change, etc.)
Motivation	How motivated one is to perform the practice, and whether this is for intrinsic or extrinsic reasons.	• Compared to other issues you face in running your business, how important to you is reducing the amount of nitrogen fertilizer that you apply to your crop? • Can you tell me why it is important to you to reduce the amount of nitrogen fertilizer you apply to your crops? Because……of the possibility of improved productivity (extrinsic); …to be seen as a good farm manager (extrinsic); …of the possibility of contributing to something worthwhile (intrinsic)
Behaviours (past and future)	Whether the practice (or precursor practices) has been used in the past, and whether there is a stated intention to trial or use certain practices in the future, in a particular situation, at a particular time.	• In the past month, have you taken any action to reduce the amount of nitrogen fertilizer you apply to your crops? • Do you intend to reduce the amount of nitrogen fertilizer you apply, the next time you fertilize your crop?

[8] For the purpose of example only, we use the case of N-reduction in cane farming to describe the types of questions that could be asked to track progress against indicators. These questions are indicative only and would need to be tested and refined with stakeholders before any application.

Group norms	Whether other land managers/ farmers in the community (with whom one has strong ties) approve of, and perform the practice themselves.	• How likely do you think it is that growers in your catchment or district have reduced the amount of nitrogen fertilizer they apply to their crops? • How many growers in your local area would think that reducing the amount of nitrogen applied to their crops is a good thing to do?
Trust	Level of trust in information sources and advice networks related to improved practices.	• How much do you trust the advice you receive from industry experts about how much nitrogen fertilizer should be used?
Cultural norms	Community- and industry-level norms that support innovation and stewardship practices.	• Are farmers in your local area encouraged to work together to develop new ways of looking after the land? (see Appendix A.1 for other example questions)
Cultural artefacts	Community- and industry-level artefacts (stories, standards, codes, rituals and communications) that encourage innovation and stewardship practices.	• How often do you attend field days where you can meet other farmers to discuss new farming practices? • How clear are the codes and standards about good farming practices that are promoted by the industry? (see Appendix A.1)

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A.1 Indicators for a culture of innovation and stewardship

CONSTRUCT	HOW ASSESSED?
Community and industry-level norms	**Farmer questionnaire (examples below)**
Success	Farmers in my local community are encouraged to have the most innovative, environmentally-friendly farm in the industry
Openness and flexibility	Farmers in my local community are encouraged to be open to new environmentally-friendly farming practices
Internal communication	Information about new ways of looking after the land is expected to be communicated throughout the local region of farmers
Competence and professionalism	Farmers in my local community are encouraged to have a high level of competence in developing and implementing new environmentally-friendly farming practices
Inter-functional co-operation	Farmers in my local region are encouraged to work together in order to develop new ways of looking after the land
	My industry organisations and leaders work with other groups (e.g. government, mills, scientists) to develop new ways of improving environmental performance of farms
Responsibility of growers	Local farmers are encouraged to take an active role in trying out new environmentally-friendly farming practices
Appreciation of growers	Farmers in my local community who implement new environmentally-friendly farming practices are recognised and rewarded
Risk-taking	Farmers in my local community are encouraged to experiment with new farming practices to improve the condition of the land
Community-and industry level artefacts	**Objective assessment (examples below)**
Stories	The number of well known stories in the community about farmers who have developed and/or implemented new environmentally-friendly farming practices
Physical arrangements	The existence (distance from farm, and regularity) of places (physical or virtual) for farmers to meet and discuss new environmentally-friendly farming practices
Standards	The presence and communication of clear codes and standards within the industry related to good practice; internal or external accreditation or compliance systems; and reported rates of information seeking/participation and/or adherence to these standards
Partnerships	The presence, commitment to and performance of inter-organisational partnerships or collaborative agreements (between government, industry or market and community-based organisations) to progress innovation in environmental performance
Rituals	The number of times the community/local industry has acknowledged and rewarded farmers who have implemented new environmentally-friendly farming practices
Language	The number of times communications have used language consistent with innovation and stewardship, such as “We could probably get some benefit from looking at this farming practice from a different perspective”

A.2 Empirical studies of farmers in the Great Barrier Reef catchment zone

VARIABLE	STUDY	FINDING
Finances	Focus groups with (predominantly sugarcane) growers in the Burdekin, Wet Tropics and Mackay catchments (Taylor & Van Grieken, 2015)	Cost-sharing grants require farmers to contribute funds. Some farmers may not have the funds to participate in Reef Rescue program. Additionally, the transaction costs borne by farmers in applying for grants can be a barrier to participation (in this instance, extension advisors provided hands-on assistance to reduce this transaction cost).
	Survey of sugarcane growers in the Wet Tropics, Burdekin and Mackay Whitsundays catchments (Rolfe & Harvey, 2017)	Most farmers held a profit and production focus, and this group were more likely to perform certain BMPs (though a lenient p=0.20 was applied). Most farmers also rated financial constraints as the significant barrier to engaging in BMPs. High fixed costs accounted for 43% of all identified barriers. When asked to nominate whether different BMPs would impact on operational costs, most growers identified that they would have no impact, and some identified cost reductions.
	Interviews with graziers in the Burdekin rangelands (Lankester, Valentine & Cottrell, 2009)	Economic reasons (cost-sharing programs, financially constrained/in debt, increasing operational costs) were cited as reasons for not investing in riparian management.
	Survey of graziers in three catchments (including the Burdekin) of the tropical savannas of northern Australia (Griener & Gregg, 2011)	Graziers self-reported top 3 most important impediments to undertaking conservation measures on the farm included 'not enough time or staff/labour', 'lack of government financial incentives', and 'loss of productivity and/or profitability'. They also rated that income tax incentives and cost-sharing for individual conservation projects would be the most effective policies in overcoming their barriers to the adoption of conservation practices.
Physical equipment	Focus groups with (predominantly sugarcane) growers in the Burdekin, Wet Tropics and Mackay catchments (Taylor & Van Grieken, 2015)	Most private commercial contractors do not have the equipment required to reduce overspray or overuse of herbicides, or do not plant at the required row spacing. Many growers therefore do not have access to the required equipment.
Awareness/acceptance of the problem	Interviews with graziers in the Burdekin rangelands (Lankester, Valentine & Cottrell, 2009)	Some graziers were not convinced that there was a sediment problem for the reef, resulting from upstream grazing activity. Scepticism expressed regarding the credibility of scientific findings, and discussion of other influences (e.g., the impacts of drought and floods on sediment problems in waterways; and the effects of feral pigs and woody weed species on riparian degradation).
	Interviews with sugarcane growers and stakeholders (Benn et al., 2010)	Many farmers, especially the older ones, want to see the evidence that fertilizer from the ground goes out to the reef and has a negative impact.
Attitudes/ Perceived benefits of the practice	Survey of graziers in the Fitzroy Basin (Fielding, Terry, Masser, Bordia & Hogg, 2005)	Graziers with strong intentions to manage their riparian zones rated all the benefits as significantly more likely and favourable, than did graziers with weak intentions ($p<0.001$).

VARIABLE	STUDY	FINDING
	Study 1 two-wave survey with horticulturalists in Queensland and Study 2 two-wave survey with graziers in Central Queensland (Fielding et al., 2008)	Landholders with more positive attitudes towards the practice had stronger intentions to manage their riparian zones (β=0.16 in Study 1, p<0.001; β=0.21 in Study 2, p<0.001).
	Survey of sugarcane growers in the Wet Tropics, Burdekin and Mackay Whitsundays catchments (Rolfe & Harvey, 2017)	Farmers identified that 'does not fit with my current farming system' as a barrier to the adoption of BMPs (though it was less important than the other barriers of 'high fixed costs' and 'requires new skills').
	Interviews with graziers in the Burdekin rangelands (Lankester, Valentine & Cottrell, 2009)	Many participants said they had adopted riparian management practices for both production and environmental reasons.
Perceived risks and costs of the practice	Survey of graziers in the Fitzroy Basin (Fielding, Terry, Masser, Bordia & Hogg, 2005)	Graziers with strong intentions to manage their riparian zones rated all the costs as significantly less negative, than did graziers with weak intentions (p<0.001).
	Interviews with sugarcane growers and stakeholders (Benn et al., 2010)	It was discussed that growers apply fertilizer as an insurance measure. Growers are conscious of the fact that reducing fertilizer application rates may result in loss of productivity and income.
	Focus groups with (predominantly sugarcane) growers in the Burdekin, Wet Tropics and Mackay catchments (Taylor & Van Grieken, 2015)	Growers advocated alternative government-funded commercial trials as a way of managing the risks associated with practice change and financial risks of up-front capital expenditure.
Perceived control	Survey of graziers in the Fitzroy Basin (Fielding et al., 2005)	Graziers with strong intentions to manage their riparian zones held a greater belief that identified barriers (with the exception of lack of money) could be overcome, than did graziers with weak intentions (p<0.001).
	Study 1 two-wave survey with horticulturalists in Queensland and Study 2 two-wave survey with graziers in Central Queensland (Fielding et al., 2008)	Landholders with a greater sense of control ('it is easy to do') had stronger intentions to manage their riparian zones (β=0.31 in Study 1, p<0.001; β=0.27 in Study 2, p<0.001).
	Survey of sugarcane growers in the Wet Tropics, Burdekin and Mackay Whitsundays catchments (Rolfe & Harvey, 2017)	When asked about barriers to engaging in BMPs, farmers tended to rate financial variables (high costs for capital; concern over meeting financial commitments; cash flow; uncertainty over selling markets) as the more significant barriers. Farmers who rated uncertainty variables (over markets and future short- or long-term climate) highly tended to be less inclined to participate in some BMPs (though we note that the significance level was lenient, at p=0.20). While high fixed costs were nominated as the most frequent barrier to engaging in BMP, the requirement for new skills and information, and 'not easy to trial' also were mentioned as barriers.
	Survey of cane-growers in Queensland (Pickering, Hong, Stower, Hong & Kealley, in press).	While the construct was labelled self-efficacy, the measure actually appears to assess control ('how important is it to you to be able to control and regulate your own farming practices?). This construct was positively related to self-rated innovation compared to other growers (p <0.05).

VARIABLE	STUDY	FINDING
General land management goals/motivations	Survey of landholders in the wet tropics of North Queensland (Emtage & Herbohn, 2012a)	Among agricultural land owners, 'building a business' was the highest-rated primary purpose for land ownership (4.35 on a scale from 0=not applicable to 5=very important). 'Improving the natural environment', and 'Keeping the property in the family and lifestyle maintenance' were also rated highly on average (3.98 and 3.90, respectively).
	Survey of sugarcane growers in the Wet Tropics, Burdekin and Mackay Whitsundays catchments (Rolfe & Harvey, 2017)	When asked about the relevance of different management goals, most farmers (71%) placed a high importance on profit and production; 18% focussed on minimising costs, and a small percentage focussed on the management of resources (7%), or lifestyle and leisure (4%). Those growers with a profit and production focus seemed to engage in more of the better BMPs (though a lenient significance level of p=0.20 was applied).
	Interviews with graziers in the Burdekin rangelands (Lankester, Valentine & Cottrell, 2009)	Many participants said they had adopted riparian management practices for both production and environmental reasons.
	Survey of graziers in three catchments of the tropical savannas of northern Australia (Greiner & Gregg, 2011)	Graziers had a very high level of conservation and lifestyle motivation, and were motivated to a lesser extent by financial/economic and social considerations. This points to a strong stewardship ethic (instrinsically motivated and altruistic) among graziers.
	Survey with cane growers in Queensland (Pickering et al., in press)	Intrinsic motivation (importance of the following to the future: their family, family's long-term survival, their children's or grandchildren's future, the GBR, and advances in scientific understanding) was not significantly correlated with BMP accreditation or other innovation-related variables.
Behaviour	Survey of graziers in the Fitzroy Basin (Fielding et al., 2005)	Past behaviour was the strongest correlate of intention to engage in riparian zone management (β=0.42, p=0.001).
	Study 1 two-wave survey with horticulturalists in Queensland and Study 2 two-wave survey with graziers in Central Queensland (Fielding et al., 2008)	Past behaviour (Are you currently engaging in any activities to manage the riparian zones on your farm? How much effort, labour and time have you put into riparian zone management) was the strongest correlate of behavioural intention (β=0.44, p=0.001 in Study 1) but was not significantly related to self-reported behaviour. The same pattern of results was observed in Study 2 with graziers. Behavioural intention was the strongest correlate of self-reported behaviour (β=0.37, p=0.001 in Study 1, and β=0.39, p=0.001 in Study 2).
Trust	Survey of landholders in the wet tropics of North Queensland (Emtage & Herbohn, 2012a)	Among agricultural land owners, neighbours (including other landholders), and productivity groups (productivity board, a semi-government agency dedicated to improving the financial and environmental performance of sugar cane growers, industry groups, the regional NRM board) were rated as reasonably trustworthy (2.3 and 2.0, respectively on a scale from 1=low trust to 3=high trust). Both the general (state government officers, local government agencies, federal government) and state government (Department of Natural Resources and Water, Department of Primary Industries), and environment groups (including landcare) were rated less favourably (1.5, 1.7 and 1.7, respectively).
	Focus groups with (predominantly sugarcane) growers in the Burdekin, Wet Tropics and Mackay catchments (Taylor & Van Grieken, 2015)	Several farmers reported underlying issues of (mis)trust between the industry/growers and government. Local relationships between farmers and extension service providers were critical to establishing trust.
	Focus groups with (predominantly sugarcane) growers in the Burdekin, Wet	Growers emphasised the importance of local advice and support networks in participating in the Reef Rescue scheme. The presence of credible and knowledgeable local advisors improved program acceptance. Extension

VARIABLE	STUDY	FINDING
Local advice, grower participation, practical learning and support	Tropics and Mackay catchments (Taylor & Van Grieken, 2015)	advisors also practically helped farmers by easing their administrative burden. Growers saw working with industry networks as beneficial (rather than through regional bodies). Extension officers supported government-funded commercial trials, as not only a way to manage the business' risk of practice change, but to also encourage a peer-based learning culture in the industry where growers work together to monitor and implement the results of farm trials.
	Survey of graziers in the Fitzroy Basin (Fielding et al., 2005)	Graziers with strong intentions to manage their riparian zones perceived greater support from referent groups (e.g., landcare) for managing riparian zones on their property, than did graziers with weak intentions ($p<0.01$ or $p<0.001$).
	Interviews with graziers in the Burdekin rangelands (Lankester, Valentine & Cottrell, 2009)	Social interaction with other producers and extension officers, especially where ideas, experiences and opinions could be shared, problems solved, and existing practices discussed were mentioned as factors that would influence their decisions regarding riparian zone management.
	Discussion and survey of cane farmers exposed to video clips of farming practices (Thomas, 2011)	Farmers who watched the video clips (conveying personal accounts of farmers' experiences adopting new technologies and practices on their farms) felt encouraged by the farmers, who provided details on practices that had eluded them. Their normative beliefs increased their confidence and self-efficacy towards practice change, which combined with existing positive attitudes, motivated them to change (actual change 32%).
	Survey with cane growers in Queensland (Pickering et al., in press)	Sugarcane growers who felt they could turn to other growers for advice was not significantly related to any outcomes at the grower-level (i.e., own innovation, BMP accreditation).
Group norms /identity	Study 1 two-wave survey with horticulturalists in Queensland and Study 2 two-wave survey with graziers in Central Queensland (Fielding et al., 2008)	Landholders who perceived that other rural/regional landholders in their community were more approving of (injunctive norms) and more likely to engage in (desciptive norms) riparian zone management, were more likely to intend to engage in riparian zone management themselves ($\beta=0.18$ in Study 1, $p<0.001$; $\beta=0.21$ in Study 2, $p<0.001$). This relationship emerged as significant only for those who were strongly identified with their rural/regional landholder group (Study 2, $p<0.05$).
	Focus groups with (predominantly sugarcane) growers in the Burdekin, Wet Tropics and Mackay catchments (Taylor & Van Grieken, 2015)	Growers discussed the undesirability of working differently from others in their district (or their co-operative harvesting group consisting of several growers).
	Survey of sugarcane growers in the Wet Tropics, Burdekin and Mackay Whitsundays catchments (Rolfe & Harvey, 2017)	Among a list of potential barriers, peer pressure to manage one's farm in a conventional manner was rated as the least important barrier to engaging in BMPs.
	Video-intervention (retrospective post-test only, non-experimental with mixed-methods) with 12 groups (n=78) of sugarcane farmers in Queensland (from Mossman to Maryborough) (Thomas, 2011)	Farmers who watched video clips of farmers' experiences adopting new technologies and practices on their farms, reported increased confidence and self-efficacy towards practice change and a willingness to change. Subjective norms (as measured via survey) were the strongest correlate of farmers' decision to adopt.

VARIABLE	STUDY	FINDING
	Survey of graziers in the Fitzroy Basin (Fielding et al., 2005)	Graziers with strong intentions to manage their riparian zones were more willing to comply with referents, than were graziers with weak intentions ($p<0.001$).
	Survey with cane growers in Queensland (Pickering et al., in press)	Sugarcane growers who felt more a part of a commmunity of canegrowers held a stronger desire to improve their farming practices ($p<0.05$).
Critical stakeholders in system (beyond the farmer)	Focus groups with (predominantly sugarcane) growers in the Burdekin, Wet Tropics and Mackay catchments (Taylor & Van Grieken, 2015)	Relationships with commercial contractors could limit some grower's capacity to move to new types of farming.
	Interviews with sugarcane growers and stakeholders (Benn et al., 2010)	Growers discussed tensions between growers and the mill. The mill has an important role to play in innovating the industry towards ecological outcomes. For example, the Mossman mill has diversified its products and produced ecologically sustainable products.By comparison, the Tully mill continues as a supplier of high quality sugarcane, and its growers have in turn diversified their products (cattle or banana production in addition to sugarcane).
Equity and fairness	Focus groups with (predominantly sugarcane) growers in the Burdekin, Wet Tropics and Mackay catchments (Taylor & Van Grieken, 2015)	Farmers who had not participated for a grant, or were unsuccessful in their application, emphasised the need to distribute funds more fairly across the industry. Farmers who were already performing the new practice or using advanced technologies were not rewarded or compensated for their efforts. The rules of the scheme gave preference to certain row spacing, which automatically ruled-out certain farmers. Growers discussed the idea of group-based trials or to work through an industry intermediary, and government-funded commercial trials (rather than competing for payments to individual farmers).
Rewards and recognition	Focus groups with (predominantly sugarcane) growers in the Burdekin, Wet Tropics and Mackay catchments (Taylor & Van Grieken, 2015)	The current grant payments do not reward or compensate farmers who are already performing the new practice or using advanced technologies.
	Interviews with sugarcane growers and stakeholders (Benn et al., 2010)	'Productivity awards, provided by the mills, are given to the most productive growers at a special annual dinner with positive media coverage including great community pride' (p. 629).
	Survey of graziers in three catchments (including the Burdekin) of the tropical savannas of northern Australia (Greiner & Gregg, 2011)	Graziers in the Burdekin also rated (in addition to income tax incentives and cost-sharing for individual conservation projects) that increased public acknowledgement of environmental achievements by graziers would be an effective policy (~3.6 on a scale from 1 to 5 with higher scores reflecting greater effectiveness) in overcoming their barriers to the adoption of conservation practices.
	Survey with cane growers in Queensland (Pickering et al., in press)	Sugarcane growers who felt that the cane industry should be better recognised for how innovative it is, and who thought that the QLD government is more supportive towards cane growers – were more likely to be BMP accredited ($p <0.05$).
Intergroup relations	Study 1 two-wave survey with horticulturalists in Queensland and Study 2 two-wave survey with graziers in Central Queensland (Fielding et al., 2008).	The more negative landholders perceived relations between urban and rural/regional Australians, the less likely they were to intend to engage in riparian zone management (Study 1, $p<0.05$). This relationship emerged for landholders who identified less with their rural/regional landholder group (Study 1 and Study 2, $p<0.10$ and $p<0.01$, respectively).

VARIABLE	STUDY	FINDING
Preferred information sources	Survey of landholders in the wet tropics of North Queensland (Emtage & Herbohn, 2012a)	Among agricultural land owners, finance and family (e.g., accountant, family, other farmers, banks) were rated as a reasonably useful source of information to assist land management (3.5 on a scale from 0=not applicable to 5=very useful). Media sources (mass media, books, internet, and brochures), enterprise groups (agribusiness agents, industry associations, private consultants, best practice groups, industry groups, and wholesalers) and environment groups (environmental groups, landcare groups, NRM groups) were rated as reasonably, to less useful on the 6-point scale (3.1, 2.7 and 2.4, respectively).

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