LAND AND WATER
www.csiro.au

Towards a human dimensions baseline

A synthesis of social research data on farming practice adoption and environmental stewardship in reef catchments

RP190 Milestones 2 & 3: Synthesis and recommendations

September 2018

Diane Jarvis, James Cook University

Bruce Taylor, CSIRO

Elizabeth Hobman, CSIRO

Citation

Jarvis D, Taylor B and Hobman E. (2018) Towards a human dimensions baseline: a synthesis of social research data on farming practice adoption and environmental stewardship in reef catchments. CSIRO and James Cook University, Australia.

Contents

Executive Summary 4

1 Introduction 6

2 Indicator themes 7

3 Methods and data sources 9

3.1 Data limitations and requirements 11

4 Data synthesis for indicator themes 14

4.1 Attitudes (towards practices) 14

4.2 Perceived behavioural control 15

4.3 Perceived barriers (control beliefs) 16

4.4 Motivation 16

4.5 Behaviours (Past and future) 18

4.6 Group norms 19

4.7 Trust 19

4.8 Cultural norms 20

4.9 Cultural artefacts 20

5 Recommendations 21

6 References 24

Appendices 26

Acknowledgements

The project team would like to acknowledge the assistance provided by several researchers and industry partners in making available recent project reports and de-identified, aggregate data sources from recently completed or ongoing research projects into land management practice adoption in the GBR, in particular, Rachel Hay, Mark Poggio, John Pickering, Matt Kealley and Sharyn Rundle-Thiele. Rachel Eberhard provided valuable feedback to the project team on monitoring and evaluation implications of the work.

Executive Summary

The Reef 2050 Water Quality Improvement Plan (RWQIP) includes objectives to improve land management and to increase a culture of stewardship amongst land managers; targets for best management practice adoption; and a human dimensions target to increase the active engagement of communities and land managers in programs to improve water quality outcomes.

This report is the second of two milestone reports. Together, these reports aim to: (i) inform Reef managers on the prospects for tracking progress towards those objectives and targets, as part of the broader monitoring and reporting requirement of the Plan, and (ii) inform the design of interventions to improve program effectiveness and practice improvement over time.

Specifically, this report presents a synthesis of suitable and available social data against the indicator themes identified in Milestone Report 1, namely: attitudes towards practices, motivations, perceived barriers, perceived behavioural control, past and future behaviour, group norms, trust, cultural norms and cultural artefacts. Broadly speaking, these indicators reflect the psychological, social and cultural factors that together help to characterise factors that influence the adoption and sustenance of positive water-quality farming practices. Combined with the outcomes of a project stakeholder workshop in August 2017 (see OGBR workshop report), this report also frames some preliminary recommendations of where to next.

There are a number of important features about the data used in this report, which for the purpose of developing a consistent baseline, serve as limitations. These include:

- data from the studies included in this report has been collected primarily from landholders who had **voluntarily participated** in land management practice improvement training or programs;
- data was drawn from a small number of landholders from **certain regions and industries** in the Great Barrier Reef catchment, and this varied across the indicator themes;
- data was gathered for **different purposes** to that of the current project, meaning, questions used to elicit information from landholders were not generally well-aligned with the indicator constructs; and,
- data on the indicator themes of culture (cultural norms and artefacts) was not readily available.

What does the data tell us?

Some of the key observations from the available data, and broadly consistent with findings in Chapter 4 of the Scientific Consensus Statement (Eberhard, 2017), include:

- Landholders generally reported positive **attitudes** towards their suite of current land management practices (including recently adopted practices associated with water quality program participation). This included very positive attitudes, including benefits to

productivity and soil health, reported towards the SIX EASY STEPS program from those growers who had completed this training.

- **Motivations** for participation and adoption differ between industry and region, and are complex, but often focus on financial responsibility, responsibility to family and responsible land stewardship (current and future).
- Landholders' want to exercise a high degree of **autonomy** when making decisions about how their land is managed and farmed (in general). This need for autonomy in decision-making has implications for how practice improvement initiatives are designed and delivered to landholders.
- There is some evidence to suggest that the **behaviour of other growers** in the local district, may influence landholders' decisions about making changes to their own farming practices.
- When receiving advice about farming practices, many graziers reported high trust in those who are close to home (other graziers they know and family), and some also reported high trust in people from regional bodies. Cane growers also tended to trust extension and technical staff associated with the industry, including the CANEGROWERS organisation and productivity services groups. Government agencies and related services are generally least trusted in practice-related decision-making.

How can we improve our measurement?

The data synthesis against the selected indicator themes points to several considerations that would help to support progress towards a human dimensions baseline:

- The need for tighter definition and clarity of purpose, audience and therefore methods required to monitor and report on psychological and social influences on adoption, environmental stewardship and innovation;
- Data collection from a range of stakeholders in the 'practice change value chain', not just landholders, including for example, advisors, program delivery agents and industry organisations;
- Where possible, standardise the method of data collection with a view to repeatability over time and access an adequately-sized, representative sample of the population of interest, not only landholders who have volunteered to participate in programs;
- Developing data collection strategies that balance the access and benefits gained by using program delivery agents, with potential limitations related to response bias because of those relationships;
- Co-design survey questions or other collection methods with stakeholders in delivery and engagement roles to improve the appropriateness of questions and measures and increase the likelihood of information gathered being of wider benefit; and
- The greater the specificity about the desired land management practice/s in the data collection process, the greater the chance of obtaining accurate information, and of developing appropriate and effective interventions on the basis of such data.

1 Introduction

The Reef 2050 Water Quality Improvement Plan (RWQIP) includes objectives to improve land management and to increase a culture of stewardship amongst land managers; targets for best management practice adoption; and a human dimensions target to increase the active engagement of communities and land managers in programs to improve water quality outcomes.

This report is the second of two milestone reports, which together, look to inform Reef stakeholders and managers on the prospects for defining and tracking progress towards those objectives and targets, as part of the broader monitoring and reporting requirement of the Plan and for the purpose of informing the design of interventions to improve program effectiveness and practice improvement over time.

Specifically we look to identify a suite of conceptually robust social indicator themes, synthesise suitable and available social data within these themes, and, consider next steps for further development of a human dimensions baseline report.

The project involved three main stages:

1. A review of peer-reviewed academic literature to conceptualise a model and propose a set of indicator themes to inform human dimensions elements of the Plan. This step will address the question "What should we measure?"
2. A review of secondary data (i.e., recent social research reports and studies[1]) 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. A 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 first stage identified nine key indicator themes, reported on within the Milestone 1 report "Understanding the human dimensions of landholder innovation and stewardship: Identifying indicators of a culture of innovation and stewardship, and land management practice change" (Hobman & Taylor, 2018). Broadly speaking, these indicators reflect the psychological, social and cultural factors that together explain a system that supports the adoption and sustenance of positive water-quality farming practices.

The current report presents the results of the second and third stages, that is, the review and synthesis of secondary data from recent and current project reports and some preliminary recommendations. This review enabled us to identify the data currently available regarding each indicator, and the gaps in our current knowledge. Combined with the outcomes of a project

[1] Secondary data includes information/data that has already been collected by another agency/entity. This study did not receive or access raw datasets, only published or provided research project reports completed largely through Queensland and/or Australian Government funded environmental research programs or funding. Secondary data contrasts with primary data, which is data collected from the original source first hand.

stakeholder workshop in August 2017, this report also frames the recommendations to inform the monitoring, evaluation and improvement needs for this new element within the Plan.

As the data incorporated into this synthesis were not collected for the purpose of preparing a social indicators baseline report, there are several important **limitations** that should be noted by the reader for this purpose. These are discussed in detail in Section 3. In light of these limits caution should be used to interpret or evaluate current performance of landholders against the indicator summaries presented here. Brief summaries of data on each indicator theme are set out within Section 4 of this report. More detailed information for each theme, including presentation of the information by region and by industry, is provided in the **appendices.**

A note to readers:

This report is a companion to the Milestone 1 report prepared for this project "Understanding the human dimensions of landholder innovation and stewardship: Identifying indicators of a culture of innovation and stewardship, and land management practice change" (Hobman & Taylor, 2018). It is in Milestone Report 1 that the reader will find the relevant peer-review literature citations that provide the basis for the definitions of concepts and selection and structure of the indicator reporting themes presented here.

2 Indicator themes

The indicator themes relevant to understanding landholder innovation and stewardship, developed within the first stage of this project (see Hobman and Taylor, 2018), are set out in **Error! Reference source not found.**1. For each of these indicators, summarised data is provided in Section 4, and more detailed information can be found within the appendices.

Table 1 Proposed indicator themes and example questions developed in stage 1 of this project (see Hobman and Taylor, 2018).

INDICATORS	DESCRIPTION	EXAMPLE QUESTIONS/MEASURES[2]
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 fertiliser 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 fertiliser 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 fertiliser you apply to your crops? • How confident are you in your ability to reduce the amount of nitrogen fertiliser that you apply to your crops? • Whether or not you reduce the amount of nitrogen fertiliser 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 fertiliser you apply to your crops? (e.g. lack of time, difficulty in calculating fertiliser requirements, cost of change, etc.)
Motivation	How motivated one is to perform the practice, and whether this is internally- (a 'want' to do) or externally-driven (a 'must' do).	• Compared to other issues you face in running your business, how important to you is reducing the amount of nitrogen fertiliser that you apply to your crop? • Can you tell me why it is important to you to reduce the amount of nitrogen fertiliser you apply to your crops? Because……of the possibility of improved productivity (external); …to be seen as a good farm manager (external); …of the possibility of contributing to something worthwhile (internal)
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 fertiliser you apply to your crops? • Do you intend to reduce the amount of nitrogen fertiliser you apply, the next time you fertilise your crop?
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 fertiliser 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 fertiliser 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?
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?

[2] 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.

The next stage, as set out below in this report, was to review and synthesise existing data against each of the indicators. By establishing our current level of understanding (by region and by industry) of these human dimensions, it will be possible to identify areas of strength, and areas for improvement across the range of indicators. More fundamentally, however, we will be able to determine whether we have sufficient information to provide a 'baseline' measure of human dimensions (across regions and industries), and if not, provide some future directions to progress this intent.

3 Methods and data sources

Data was sourced and reviewed from recent empirical studies, conducted with farmers in the Great Barrier Reef catchment zone, that have provided secondary data relating to the human dimensions indicator themes. Publicly available reports were provided in response to an email request made by staff of the Office of the Great Barrier Reef directly to researchers known to have conducted research in this field in the recent past. In order to assess the suitability of and availability of contemporary data sources the project steering committee decided to limit the time period of 'relevant data' from 2016/17 to present. Reports based on data collected prior to 2016 were not incorporated. The available data was collated, summarised and mapped against the set of indicator themes to provide the synthesis of our current knowledge.

The sources of the data used within this report are set out within

Table .

Table 2 Sources of data used for this report.

INDICATOR THEME	REGION	INDUSTRY	DATA USED : NUMBER OF RESPONSES, TIMING AND SOURCE OF DATA
Attitudes (towards the practice)	Burdekin	Grazing	80 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a)
		Cane	38 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a), and 20 responses during June 2017 (Social Marketing @ Griffith, 2017)
	Wet Tropics	Cane	248 responses during early 2017 (Farr, Eagle, et al., 2017b)
		Bananas	46 responses during mid 2017 (Cook et al., 2018)
	GBR catchments	Grazing	156 responses largely from Eastern Queensland during late 2017 (Rolfe & Star, 2018)
Perceived behavioural control	Burdekin	Grazing	80 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a)
		Cane	54 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a), 14 responses during 2017 (NQ Dry Tropics, 2017), and 20 responses during June 2017 (Social Marketing @ Griffith, 2017)
	Wet Tropics	Cane	248 responses during early 2017 (Farr, Eagle, et al., 2017b) and 48 responses during 2016 (Behaviour Innovation, 2016)
		Bananas	-
Perceived barriers	Burdekin	Grazing	-
		Cane	14 responses during 2017 (NQ Dry Tropics, 2017)
	Wet Tropics	Cane	48 responses during 2016 (Behaviour Innovation, 2016)
		Bananas	46 responses during mid 2017 (Cook et al., 2018)
Motivation	Burdekin	Grazing	80 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a)
		Cane	54 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a)
	Wet Tropics	Cane	248 responses during early 2017 (Farr, Eagle, et al., 2017b) and 48 responses during 2016 (Behaviour Innovation, 2016)
		Bananas	-
Behaviours (past and future)	Burdekin	Grazing	80 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a)
		Cane	38 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a), 14 responses during 2017 (NQ Dry Tropics, 2017), and 20 responses during June 2017 (Social Marketing @ Griffith, 2017)
	Wet Tropics	Cane	248 responses during early 2017 (Farr, Eagle, et al., 2017b)
		Bananas	46 responses during mid 2017 (Cook et al., 2018)
Group norms	Burdekin	Grazing	80 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a
		Cane	38 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a)
	Wet Tropics	Cane	248 responses during early 2017 (Farr, Eagle, et al., 2017b) and 48 responses during 2016 (Behaviour Innovation, 2016)
		Bananas	-
Trust	Burdekin	Grazing	80 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a
		Cane	38 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a) and 14 responses during 2017 (NQ Dry Tropics, 2017)
	Wet Tropics	Cane	248 responses during early 2017 (Farr, Eagle, et al., 2017b) and 48 responses during 2016 (Behaviour Innovation, 2016)
		Bananas	-
Cultural norms	Burdekin	Grazing	80 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a
		Cane	54 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a)
	Wet Tropics	Cane	248 responses during early 2017 (Farr, Eagle, et al., 2017b) and 48 responses during 2016 (Behaviour Innovation, 2016)
		Bananas	-
Cultural artefacts	Burdekin	Grazing	58 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a
		Cane	41 responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a) and 20 responses during June 2017 (Social Marketing @ Griffith, 2017)
	Wet Tropics	Cane	246 responses during early 2017 (Farr, Eagle, et al., 2017b)
		Bananas	-

3.1 Data limitations and requirements

There are several issues that relate to the application of the data used for the synthesis that, broadly, pertain to sampling and measurement.

The data relates to a small number of land managers, most of whom had volunteered to participate in a land management practices improvement program, and does not cover all of the regions relevant to each industry within the GBR catchment region.

Due to the data mainly having been drawn from landholders who had voluntarily participated in industry land management practice improvement programs, this may have introduced bias into the sample, as landholders who participate in programs are likely to be more motivated than those who do not participate. They may also differ on other aspects (e.g., financial capability, technical skill). Ultimately, this means that any conclusions drawn from the data can only represent the unique cohort of landholders who participate in programs, and not the broader population of landholders. For example, the data indicated that the majority of graziers and cane farmers have already adopted the desired farming practices (e.g., changed farming practices to control nitrogen loss). Whether this result holds for the broader population of farmers remains unknown.

The data was drawn from a small number of landholders from certain regions and industries in the Great Barrier Reef catchment, and this varied across indicators. The lack of comprehensive, standardised data therefore precludes a comparative assessment of indicators, regions and industries (data on all indicators from a single, large sample of landholders, would be required to facilitate such). It also means that for any single indicator, it is impossible to generalise to other industries and/or regions across the catchment as a whole. Ultimately, this means that any conclusions drawn from the data can only represent the landholders of a given region and industry (as well as those landholders who volunteer for programs as discussed above).

Furthermore, the data included in this synthesis was gathered for different purposes to that of the current exercise. Thus, the questions used to elicit information from landholders were not always well-aligned with the indicator constructs. For example, landholders may have been questioned about their goals for their farm/property in general – rather than being asked about their motivations for performing new farming practices (that benefit water quality). This means that the assessment of some indicators lacked construct validity[3] when applied to our indicators, and/or content validity[4] was poor.

Data on the indicators of culture (cultural norms and artefacts) was not readily available. This is partly because the reports we reviewed may not the best source of information on these variables. Alternative data sources may be required, particularly for the assessment of cultural artefacts – for example, a thematic analysis of media and communication materials on a commodity or regional basis.

[3] Construct validity refers to the degree to which a test (or question in our case) measures what it claims to be measuring.

[4] Content validity refers to the extent to which a measure represents all facets or dimensions of a given construct/variable.

It is also important to note that whilst some variations are noted across different industries and different spatial regions, information is not available in all cases regarding the statistical significance of these differences. The implication of a lack of data and a lack of statistical testing is that we may be unable to assess whether the differences were meaningful.

There was very minimal information available for any of the indicators regarding specific new farming practices (such as nitrogen fertiliser reduction and riparian zone management). Given the remit is to evaluate progress towards the adoption of new land-management practices that benefit water quality, it is important that those specific land management practices are well defined to begin with, and are the focus of questions.

The table over (Table 3) provides a synopsis of how these limitations affected each of the indicators, and visually summarises the current data quality and availability.

Table 3 Synopsis of data limitations related to each indicator. White squares indicates no data available for the study time period (2016/17 to present). Grey squares indicate some data was available.

REGION	INDUSTRY	APPROX. NO. OF FARMERS[5]	ATTITUDES (TOWARDS THE PRACTICE)	PERCEIVED BEHAVIOURAL CONTROL	PERCEIVED BARRIERS	MOTIVATION	BEHAVIOURS (PAST AND FUTURE)	GROUP NORMS	TRUST	CULTURAL NORMS	CULTURAL ARTEFACTS
Cape York	Grazing	48									
Wet Tropics	Grazing	935									
	Sugarcane	1,343									
	Bananas	250									
	Other horticulture	80									
Burdekin	Grazing	983									
	Sugarcane	556									
	Horticulture	192									
Mackay Whitsunday	Grazing	416									
	Sugarcane	1,380									
	Horticulture	33									
Fitzroy	Grazing	3,666									
	Horticulture	106									
	Grains	600									
Burnett Mary	Grazing	2,495									
	Sugarcane	498									
	Horticulture	280									
Comments on availability			Some, for cane-and banana growers involved in programs, but data mainly relates to current (loosely specified) practices not towards desired practices	Data generally relates to general perceived control over farm management rather than specific control relating to adoption of changed land management practices. No data was collected on efficacy.	Some, especially for cane-and banana growers involved in programs, but data relates to perceived barriers towards generically defined change in practice rather than to specific desired practices	Data generally relates to general business and land management goals and priorities rather than to adoption of specific practices	Some, especially for cane-and banana growers involved in programs, but data mainly relates to general categories of behaviours rather than to specific desired practices	Data generally relates to perceptions of whether loosely specified current practices are those used by other farmers, or those farmers that are respected, rather than whether the farmer considers other farmers to have adopted the desired practices	Data generally relates to those trusted to advise on current practices rather than with regard to the adoption of new desired land management practices	Minimal data available	Minimal data available
Outstanding data needs			Assessment of attitudes towards the specific desired practices. Assessment of broader population of landholders	Assessment of perceived control regarding adoption of the specific desired practices. Assessment of broader population of landholders	Assessment of perceived barriers preventing adoption of the specific desired practices Assessment of broader population of landholders	Assessment of motivations for adopting the specific desired practices. Assessment of broader population of landholders	Assessment of whether the specific desired practices have been adopted in the past or plans are in place for future adoption. Assessment of broader population of landholders	Assessment of whether other farmers are perceived to have adopted the specific desired practices. Assessment of broader population of landholders	Assessment of who would be trusted to advise on changing to the desired practices. Assessment of broader population of landholders	Assessment of norms regarding innovative practices in the local community. Assessment of broader population of landholders	Collection of data from alternative sources (e.g., media and communications analysis).
Overall suitability score for available data **(1= Very limited data and not relevant; 2= Very limited data, limited relevance for limited industries and/or regions; 3= Limited amount of data with some relevance, available for some industries and/or regions)**			3	2	3	1	3	2	2	1	1

[5] 2013 data from 2012-13 Reefplan report cards for each region https://www.reefplan.qld.gov.au/measuring-success/report-cards/2012-2013-report-card/

4 Data synthesis for indicator themes

4.1 Attitudes (towards practices)

4.1.1 Definition

This theme addresses landholders' attitudes towards (i.e., overall evaluation of, or beliefs about) practices aimed at improving water quality. These attitudes can be positive or negative, and may include an assessment of how attractive, beneficial, harmful and/or risky the new practice is considered to be, both absolutely and relatively (i.e. compared to the current practice). The relative advantage of a given practice may include enhanced benefits and/or reduced costs, and could be of a financial and/or non-financial nature. If the landholder holds negative attitudes towards the practice and perceives that it offers little advantage (or is even disadvantageous) over their current practices, adoption is likely to be impeded.

4.1.2 Summary of findings

- From around half to the majority of cane and grazing landholders have positive perceptions of their current farming practices with regard to meeting their personal goals, maintaining good cash flow, reducing business risk and being the most effective way of controlling erosion/nutrient loss. Positive perceptions varied depending on the industry (cane, grazing), the practice under examination and the region. These current practices may or may not be desired practices, as the questions asked in previous research did not explicitly measure attitudes towards specific desired land management practices.
- Between one-third and two-thirds of cane and grazing landholders hold positive perceptions of their current farming practices with regard to these practices being the least time consuming (or labour intensive). Generally cane growers were more positive about their current practices than graziers however perceptions varied across regions, industries and practices. This suggests that a significant number of landholders believe there are few gains to be made through practice changes that promote greater time-efficiency or reduced labour intensity.
- Of those cane farmers that completed a SIX EASY STEPS practice change training program, a large majority reported they have positive attitudes towards the new practices, with regard to both profitability (95.0%) and soil health (70.0%).
- The majority of cane and grazing landholders have applied for grants or financial assistance over the last 5 years (67.7%), and those that have received assistance have found this to be useful or extremely useful.

4.1.3 Observations and recommendations for future program development

Landholders generally report positive attitudes towards their current land management practices. Education and extension activities may be required to help landholders learn about the possible improvements that could result from alternative practices, which may encourage a re-evaluation of their attitudes to their current practices.

4.2 Perceived behavioural control

4.2.1 Definition

Perceived behavioural control is comprised of two components: how easy or difficult people believe it is to perform the desired practice (self-efficacy or capability), and whether they believe changing to this new practice is within their control (perceived controllability). If the characteristics of a new practice are such that landholders perceive it to be overly complex or difficult to trial (such as in the presence of too many barriers, or outside their skill base) then they may consider adoption to be beyond their control and that they do not have the personal ability to perform the practice. Likewise, they are unlikely to adopt a new practice if they perceive this decision to exceed their own personal authority and go beyond the boundaries of their own perceived level of controllability.

4.2.2 Summary of findings

- The vast majority of landholders (>90%) agree that it is important to be in control over decisions made regarding land practice changes.
- The majority of landholders (>85%) perceive that they are the main decision makers regarding the land management practices undertaken on their land (either alone or together with family members).
- A small proportion (<10%) of landholders report that some factor (frequently unspecified, but specific factors identified included factors due to the climate and natural environment, and imposed regulations) beyond their perceived behaviour control forces them to undertake their current practices.

Most of the available data measured perceived controllability regarding farming practices and decisions (in general). The one exception to this was the assessment among cane growers of their self-efficacy in using, or confidence in their ability to use and maintain, the 6ES. Approximately two-thirds of cane growers who completed SIX EASY STEPS were confident they could maintain the new practices they adopted into the future.

4.2.3 Observations and recommendations for future program development

Landholders generally report that it is important for them to feel that they are in control over decisions that relate to their property, reflecting a strong desire for autonomy. This indicates that practice change programs may be successful if designed and delivered in such a way that affords landholders control, whilst there could be strong resistance to programs perceived to involve increased regulations or other mandated requirements to behave in a particular manner.

Additionally, it may be important for programs to develop landholders' sense of confidence and belief that they have the ability to continue engaging in the desired practices upon program completion.

4.3 Perceived barriers (control beliefs)

4.3.1 Definition

This indicator focuses on the extent to which landholders perceive that certain barriers are impeding or preventing them from performing particular practices. These barriers can include but are not limited to insufficient financial or human capital. The belief that there are factors which hinder practice performance are known as 'control beliefs'[6]. Knowledge of the exact factors that may be preventing changes in practice performance can help inform program design.

4.3.2 Summary of findings

- Very limited data available for this indicator, with no data relating to graziers.
- A perceived culture of blame is considered to be a barrier to behaviour change by cane farmers.
- Around a quarter of sugar growers, and some banana growers (proportion not available) perceive some barriers to relate to financial and current equipment/practices factors. The strength of the barrier varies depending on the particular practice being evaluated (e.g. BMP fertiliser application methods for banana growers perceived to require high capital investment, thus providing a financial constraint to adoption).
- Time and skill factors are also reported as potential barriers to the adoption of certain practices, by some landholders.

4.4 Motivation

4.4.1 Definition

This theme refers to landholder motivation to perform a new practice, and whether the source of the motivation is internal or external. Internal (or autonomous) motivation is something a landholder does for internal reasons – to feel satisfied, experience enjoyment or a personal sense of purpose/meaning. External (or controlled) motivation is something a landholder feels they do for external reasons – to obtain a financial reward or to meet social expectations/approval. Motivation is usually represented on a continuum with intrinsic motivation on one end, amotivation (lacking motivation) on the other end, and varying levels of extrinsic motivation (which include varying degrees of external and internal sources of motivation). Where a landholder is motivated to engage in practices for internal reasons, it is likely that there will be

[6] Control beliefs differ from perceived behavioural control (PBC) in that control beliefs unpack the specific barriers that people perceive are serving to limit or control performance of the behaviour. Perceived behavioural control is related to control beliefs, however, PBC is a more generalised, global assessment of whether one feels that performing the behaviour is within one's control.

high levels of adoption and persistence of practice; whereas if a landholder is motivated for external reasons, then they may only engage in the practice in the presence of these external factors.

More broadly, general motivation may be assessed by measuring relative importance: if a landholder considers that spending time on a particular practice is more important (i.e. a higher priority) than other activities on the farm, then the likelihood of adoption may be greater.

4.4.2 Summary of findings

- The data suggests that the motivation of graziers and cane farmers towards the land management practices adopted is derived from both internal and external factors, which provide benefits for landholders and their families. That is, motivation is derived from a mix of factors based around looking after their own land today and for their families into the future, looking after their family (all internal motivating factors), and looking after their finances (external motivating factor). The mix of motivational factors is complex and varies by landholder industry and location, and thus cannot be expressed by one simple measure.
- In addition to being motivated by caring for their own lands, cane farmers were found to be more strongly motivated than graziers by wider environmental factors (e.g. helping to safeguard the GBR), by social factors (e.g. having efforts recognised by the wider community) and by financial factors (e.g. keeping farm costs low)[7].

Observations and recommendations for future program development

Landholders report being motivated by a range of internal and external factors that ultimately bring benefits to their own farm and family. This suggests that practice change initiatives should be designed and delivered in such a manner that helps landholders achieve as many farming goals as possible (e.g., looking after the land and water, making autonomous decisions, increasing productivity, minimising costs). Importantly, significant problems are likely to arise if practice change initiatives clearly threaten the attainment of any one important goal. For sugar cane growers, reducing fertilizer usage obviously puts productivity (higher sugar content) at risk (even if this risk is a perception). And for graziers, managing riparian zones may challenge landholders' desire to minimise costs (in the short-term). In these instances, program designers will need to include additional strategies to offset these threats. For example, cane growers could share their results of trials showing sugar content under various fertilizer usage conditions, and discuss additional farming methods for improving sugar content (to serve as risk-control measures). The fact that landholders are motivated by internal factors aligned with environmental stewardship (i.e., leaving the land in better condition, passing on a healthy property), also indicates that practice change programs should not exclusively rely on monetary incentives (e.g., grants) as this may serve to diminish any internal motivation that may be present among landholders (known as the 'crowding out' effect).

[7] Significant differences found between responses of cane farmers and graziers in the Burdekin (Farr, Eagle, & Hay, 2017).

4.5 Behaviours (Past and future)

4.5.1 Definition

This indicator focuses on whether the landholder has used a desired practice (or precursor practice) in the past, and whether there is a stated intention to trial or use certain desired practices in the future, in a particular situation, at a particular time. Past behaviours are frequently strong predictors of future behaviour as are intentions to perform a behaviour in the future (especially when tied to a specific place and time). Thus, in the case where landholders have indicated that they are already engaging in the desired practices, or intend to do so (by saying when, where and how), then it is likely that they will perform the practice in the future.

4.5.2 Summary of findings

- The majority of graziers and cane farmers surveyed have adopted at least one practice broadly categorised as contributing to improved water quality (even if not best management practice).
- Vast majority of cane farmers and graziers (>92%) are not anticipating changing their current land management practices in the following year. There is insufficient information to determine the proportion of these current practices (where no change is planned) that are best management practice for improving water quality.
- Of those cane farmers that completed a SIX EASY STEPS practice change training program, a majority stated they have adopted desired behaviours (>80%) and are confident these can be maintained (>63%) (NB: confidence that practices can be maintained is strongly related to *Perceived Behavioural Control*, above).
- A majority of the banana growers surveyed (>72% of 46 growers) perceive that they have already adopted best management practices.

Observations and recommendations for future program development

The limited data available suggests that once landholders participate in water quality related practice improvement programs, then there is a period of time in which further improvement or additional changes may be unlikely (e.g. in the 12 months following the initial change). However there does appear to be the need for 'follow-up' or support activities that would improve the confidence land managers have in their ability to maintain the new practice. This is particularly important if the practice is a foundational one that provides a platform for future improvement.

4.6 Group norms

4.6.1 Definition

This indicator addresses whether other land managers/farmers in the community (with whom one has strong ties) approve of, and perform the desired practices themselves. In a number of behavioural domains, people are influenced by what other people do, and the norms (i.e., the pattern of behaviour in a group that is considered normal, common and accepted) of those groups for which landholders have the strongest ties (family, friends, other landholders) are considered to have the strongest influence over the landholders behaviour. Where landholders perceive group norms that endorse desirable practices, it is likely that they themselves will conform to these norms and enact the practices too.

4.6.2 Summary of findings

- Around half of landholders surveyed believe their current practices (that can influence water quality) are the practices adopted by the landholders they respect.
- There is some evidence to suggest that canefarmers perceive that their future behaviours may be influenced by the behaviours of other growers and of the wider community.
- Cane farmers do feel group ties, with being a cane grower forming part of their identity and being a source of pride.

4.7 Trust

4.7.1 Definition

This indicator focuses on the level of trust that landholders have in information sources and advice networks related to improved practices (such as extension service providers or other program delivery agents). Trust in advice is proposed to be a key influencer in landholders' decision-making about new or changed practices.

4.7.2 Summary of findings

- Graziers place the most trust in the advice they receive from family who are also graziers and other graziers.
- Cane farmers place the most trust in the advice they receive from industry extension offices, private agronomists, family who are also cane farmers, and other cane farmers, with regard to current practices, and place the most trust in productivity service groups, CANEGROWERS association, and other growers when considering changing practices.
- Cane farmers place very little trust in advice from people within government departments.

4.8 Cultural norms

4.8.1 Definition

This indicator focuses on community- and industry-level norms (shared expectations and rules that guide behaviour in the community/industry) that encourage innovation and environmental stewardship (e.g., community norms where it is common for farmers to come together to share ideas and test out new farming practices). A culture where landholders are enabled and encouraged to develop or demonstrate skilled management and innovative practices themselves, rather than imposing these practices upon landholders, can foster the development of embedded cultural capital, which may then lead to the establishment of new cultural norms (regarding water-quality farming practices).

4.8.2 Summary of findings

- The available data did not correspond well to this indicator, such that a comprehensive assessment was not possible.
- However, there was data showing that cane farmers and graziers believe it is important to share new ideas with others.
- Additionally, cane farmers and graziers believe it is important to be able to learn about, and test, new land management practices.

4.9 Cultural artefacts

4.9.1 Definition

This indicator focuses on community and industry level artefacts that encourage a culture of innovation and environmental stewardship. These artefacts include stories, standards, codes, rituals or communications that are common, visible and persistent in an industry or community and that reinforce and perpetuate a culture of innovation and environmental stewardship.

4.9.2 Summary of findings

- The available data did not correspond well to this indicator, such that a comprehensive assessment was not possible.
- However, there was data showing that many landholders have participated in workshops, training programs and extension activities over the last 5 years; representing around half of graziers and cane farmers in Burdekin, and over 90% of cane farmers in Wet Tropics.

5 Recommendations

The data synthesis set out within this report sought to assess the current state of information in relation to each of the proposed indicator themes. In doing so, observations of some recurrent themes and other insights were identified that may serve to inform current thinking on program design or prioritisation of indicators:

- Landholders generally reported positive **attitudes** towards their suite of current land management practices (including recently adopted practices associated with water quality program participation). This included very positive attitudes, including benefits to productivity and soil health, reported towards the SIX EASY STEPS program from those growers who had completed this training.
- **Motivations** for participation and adoption differ between industry and region, and are complex, but often focus on financial responsibility, responsibility to family and responsible land stewardship (current and future).
- Landholders' wish to exercise a high degree of **autonomy** in decision-making over how their land is managed and farmed, and as such, this is likely to be an important dimension of successful practice improvement initiatives.
- There is some evidence to suggest that the behaviour of other growers and farmers in producers' networks is highly influential in future adoption decisions.
- When receiving advice about farming practices, many graziers reported high trust in those who are close to home (other graziers they know and family), and some also reported high trust in people from regional bodies. Cane growers also tended to trust extension and technical staff associated with the industry, including the CANEGROWERS organisation and productivity services groups. Government agencies and related services are generally least trusted in practice related decision-making.

More generally, it is noted that the current data available is not sufficient to give us a reliable understanding of the current status of each theme. More specific data, gathered from landholders across the GBR catchment regions is required to facilitate the development of a reliable and representative baseline against which future progress can be measured. In order to develop a suite of suitable indicators to inform the monitoring, evaluation and improvement needs for the Plan, we propose the following actions. These actions should help progress the development and refinement of a robust human dimensions baseline:

- Be clear about the intended purpose of the baseline activity, in terms of key aims, target activities being assessed, and end-users of the information for decision-making or interventions. For example, data may be collected to track progress towards defined practice adoption targets as set by senior policy and program staff in OGBR, but such data may also be useful for program evaluation, learning and improvement purposes (e.g. improving extension practice). It will be important to articulate the primary purpose of the baseline assessment and to clearly specify where ancillary benefits exist and are permitted.
- Consider the most appropriate methods for data collection and reporting, keeping in mind the defined purposes. For example, for program evaluation purposes, surveying and/or interviewing program participants by a person not directly involved in project delivery may

be appropriate. Whereas, tracking progress towards adoption targets may involve OGBR conducting a broader scale survey of the broader population of landholders.

- Collect data from a range of stakeholders in the 'practice change value chain', not just landholders, in order to comprehensively assess the culture of innovation and stewardship and to triangulate the findings derived from landholders. These other stakeholders could include for example, advisors, resellers, and program extension and delivery agents, agricultural industry representative organisations.
- If survey methods are decided upon, then where possible, standardise the method of surveying (because responses may vary depending on how the survey is delivered[8]). However practically-speaking, this might be impossible, and as such, it will be important to include a data field to denote the method of surveying (which can then serve as a statistical control in subsequent analysis).
- Survey an adequately-sized, representative sample of the population of interest, not just landholders who have volunteered to participate in a program (and with that group, survey them prior to program start, not just at the completion of the program). This sample may be stratified across industries and geographic location to enable sub-group analysis. Alternative methods may be required to survey hard-to-reach segments of the population – for example, surveying at industry events, via social media; and potentially offer a small incentive for participation.
- Where delivery agents and other service providers are involved in the gathering of information from landholders, this strategy can improve access, improve service provider learning and relationship development and increase completion rates of the survey or data gathering instrument. However this should be weighed against disadvantages such as response bias that may stem from the closeness of that relationship and from the interests of both parties in communicating successful delivery outcomes. Data collection strategies such as the provision of a reply-paid envelope (labelled confidential) addressed to a research officer, or a large box for the collection of surveys at an event can help to increase landholders' sense that they can be open and honest in their responses.
- Co-design survey questions with stakeholders who are in service delivery roles so that the questions are easy and straightforward for landholders to answer. Working closely and collaboratively with delivery agents and other stakeholders who have a primary interest in the information being collected (such as industry groups) can help ensure data gathering is tailored to specific contexts and needs, and increase the likelihood of information sharing between stakeholders.
- Ensure that the desired water-quality landholder practices are well-defined and understood by landholders. As most of the indicators are focussed on a particular practice, it will be important to clarify what this practice is in a commodity and geographically relevant way. The greater the specificity about the desired practice, the greater the chance of developing appropriate and effective interventions from the data collected. However

[8] Face to face interview with researcher or extension officer, self-completed questionnaire, web-based survey etc.

this specificity for a given time period may reduce the capacity of managers to track progress towards targets over multiple years given the tendency for these practices to be modified or replaced with the advent of new recommendations or new technologies.

6 References

Behaviour Innovation. (2016). Project Cane Changer Dataset.

Cook, S., Harvey, S., Connolly, C., & Poggio, M. (2018). Economic assessment of best management practices for banana growing, Report to the Department of Environment and Science through funding from the Reef Water Quality Science Program, RP140B Adoption Innovation Profile Report. Department of Agriculture and Fisheries (DAF).

Eberhard, R., Thorburn, P., Rolfe, J., Taylor, B., Ronan, M., Weber, T., Flint, N., Kroon, F., Brodie, J., Waterhouse, J., Silburn, M., Bartley, R., Davis, A., Wilkinson, S., Lewis, S., Star, M., Poggio, M., Windle, J., Marshall, N., Hill, R., Maclean, K., Lyons, P., Robinson, C., Adame, F., Selles, A., Griffiths, M., Gunn, J., McCosker, K., 2017. Scientific Consensus Statement 2017: A synthesis of the science of land-based water quality impacts on the Great Barrier Reef, Chapter 4: Management options and their effectiveness. State of Queensland, 2017.

Farr, M., Eagle, L., & Hay, R. (2017). Questionnaire Design, Sampling Strategy and Preliminary Findings: A Comparison of the Burdekin and Wet Tropics regions. NESP Project 2.1.3 Interim report. Report to the National Environmental Science Program. Reef and Rainforest Research Centre Limited, Cairns.

Farr, M., Eagle, L., Hay, R., & Churchill, M. (2017a). Questionnaire Design, Sampling Strategy and Preliminary Findings: The Burdekin region NESP Project 2.1.3 Interim report. Report to the National Environmental Science Program. Reef and Rainforest Research Centre Limited, Cairns.

Farr, M., Eagle, L., Hay, R., & Churchill, M. (2017b). Questionnaire Design, Sampling Strategy and Preliminary Findings: The Wet Tropics region. NESP Project 2.1.3 Interim report. Report to the National Environmental Science Program. Reef and Rainforest Research Centre Limited, Cairns.

Hobman, E., & Taylor, B. (2018) Understanding the human dimensions of landholder innovation and stewardship: Identifying indicators of a culture of innovation and stewardship, and land management practice change. CSIRO, Australia.

NQ Dry Tropics. (2017). EHPS16 Social study summary of barriers and benefits of practice change for Lilliesmere and Horseshoe Lagoon cane farmers.

Rolfe, J., & Star, M. (2018). Producers risk attitudes and implications for management Report 2 for Project Pioneer. CQ University, Australia.

Social Marketing @ Griffith. (2017). Burdekin Cane Grower's Experience with RP161: Social Research Survey. Griffith University, Queensland.

The State of Queensland (2017). Reef 2050 Water Quality Improvement Plan 2017-2022. Published by the Reef Water Quality Protection Plan Secretariat.

Appendices

A.1 Attitudes (towards the practice)

A.1.1 Relevant measures adopted in previous research

The questions asked in previous research did not explicitly measure attitudes towards specific desired land management practices. Instead, they focus on broader categories of farming practices (e.g., the benefits of calculating fertiliser application rates, or handling run-off from irrigation/rainfall) rather than specific practices tied to water quality improvements (e.g., the benefits of calculating fertiliser application rates in a way that minimises nitrogen run-off, or handling run-off to minimise nitrogen loss). Nonetheless, this data provides some useful insights into the attitudes of landholders, as these more general practices are likely to overlap with more specific practices. We also note that the studies for graziers and cane farmers referred to broadly-defined practices whilst the practices used in the study of banana growers were more specific.

Question set 1

This question set assessed the perceived benefits of certain practices (Farr, Eagle, & Hay, 2017; Farr, Eagle, Hay, & Churchill, 2017a, 2017b). After being asked to indicate whether they performed a certain practice, they were then asked whether that practice was:

a) the best way to meet their personal goals,
b) the best way to maintain good cash flow,
c) the best way to reduce business risk,
d) the least time-consuming, and
e) the most effective way of controlling nutrient loss (for cane farmers) or erosion on the property (for graziers).

Question set 2

This question set addressed landholders attitudes towards specific practices or programs (whether currently adopted or not), focusing on:

a) The attitudes of landholders with regards to the likely economic impacts of a number of specified best management practices (whether adopted by that landholder or not) (Cook et al., 2018).
b) The attitudes of landholders towards, and perceptions of, the risks that might be involved in entering into either grant or tender schemes to improve water quality into the Great Barrier Reef (Rolfe & Star, 2018)
c) The attitudes of landholders towards specific practices following completion of a specific behaviour change program (Social Marketing @ Griffith, 2017)
d) The attitude of landholders towards specific grants and assistance programs they have previously been involved in (Farr, Eagle, et al., 2017a, 2017b).

A.1.2 Grazing summary

The data for graziers relates to attitudes towards broad categories of practices and towards risks that may arise from participating in a Government-funded WQ improvement scheme.

In general, graziers have positive attitudes to their current practices, believing that their approach to spelling paddocks, adjusting stock numbers to paddock conditions and managing stock around waterways is the best way to meet their personal goals, to maintain good cash flow and to control erosion on their property (and we note that the majority, i.e., ~70% to ~95%, of the sample had adopted practices within these categories). Particularly with regard to the spelling of paddocks during wet periods and stock management around waterways, the majority (~80%) agreed that these practices were the best way to achieve personal goals. Slightly less (~60 to 70%) agreed that these practices were beneficial to good cash flow, reducing business risk and controlling erosion. Interestingly, although the vast majority had adopted the practice of adjusting stock numbers to paddock conditions, only around 50% to 60% thought that this practice was beneficial. Across the board, around one-third perceived the practices as least-time consuming or labour-intensive.

The graziers' attitude to entering into grant and tender schemes funded by Government to improve WQ into the GBR focused most strongly on risks of required paperwork or increased management time; only a small proportion perceived risks of production losses or increased costs or restrictions on their ability to manage during dry years. This implies that participation could be increased by streamlining/simplifying processes such that less paperwork/ management commitment is required.

Almost half the graziers had applied for grants or financial assistance during the last 5 years, and those that received assistance found this to be extremely useful.

Apx Table.1 Grazing summary data

Question/concept	**Geographic region**			
	GBR catchments**	**Burdekin***		
Question set 1				
Practice		Spelling paddocks during most recent wet period	Adjusting stock numbers to paddock conditions	Stock management around waterways
% graziers adopting practice	Not available	72.0%	96.30%	81.5%
Of the graziers that have adopted these practice, their perceived benefits of current practices:				
Best way to meet my own personal goals	Not available	77.8%	55.5%	77.8%
Best way to maintain good cash flow	Not available	59.2%	50.0%	64.8%
Best way to reduce business risk	Not available	59.3%	48.2%	72.2%
Least time-consuming (or labour intensive)	Not available	37.1%	33.4%	37.1%
Most effective way of controlling erosion	Not available	61.1%	59.2%	61.1%

Question/concept	Geographic region			
	GBR catchments**	Burdekin*		
Question set 2				
Perceived risks reported by graziers relating to entering into grant and tender schemes funded by Government to improve WQ into the GBR were as follows:				
Paperwork	31%	Not available	Not available	Not available
Increased management time	18%	Not available	Not available	Not available
There are no risks	16%	Not available	Not available	Not available
Uncertainty about the costs	12%	Not available	Not available	Not available
Possible losses in production	8%	Not available	Not available	Not available
Not sure	7%	Not available	Not available	Not available
Increased costs	4%	Not available	Not available	Not available
Ability to manage in dry years	4%	Not available	Not available	Not available
Graziers were asked whether they had applied for grants and financial assistance during the last 5 years to enable them to do things on their property				
% who did apply during the last 5 years	Not available	44.3%		
Graziers were asked which grants and financial assistance they had applied for, and how useful they had found it (usefulness score assigned where 1 = complete waste of time to 7 = extremely useful). Only types applied for by >5% of respondents listed below.				
Drought assistance	Not available	20.0% applied, mean score 7.0		
Water	Not available	18.2% applied, mean score 7.0		
Reef Rescue	Not available	9.1% applied, mean score 7.0		
Fencing	Not available	7.3% applied, mean score 6.7		
NQDT erosion control	Not available	5.5% applied, mean score 6.3		

Note. *Burdekin data is based upon survey responses from 80 graziers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, et al., 2017a). **GBR catchments data is based on responses from 156 beef cattle producers, largely from Eastern Queensland who participated in two workshops during late 2017 (Rolfe & Star, 2018).

A.1.3 Cane summary

The data for sugarcane farmers relates to their attitudes to their current practices within the three broad categories of behaviours described as 'Irrigation practices – use of tools', 'calculating fertiliser application rates' and 'handling run off from rainfall and irrigation'.

Some differences can be seen in the adoption of, and attitudes towards, practices between the two regions. The use of irrigation is used by the vast majority (>90%) of growers in the Burdekin but by only a small proportion (<20%) in the Wet Tropics. Whilst a larger proportion of growers in the Wet Tropics calculate fertiliser application rates (55%) and handle run off (64%) compared to the Burdekin growers (45% and 47%, respectively), tests for significant differences were inconclusive. Differences between the mean responses for each of the regions are generally not significantly different, other than regarding calculating fertiliser application rates for meeting

personal goals and being least time consuming, and regarding handling run off for being least time consuming (Farr, Eagle, & Hay, 2017)[9].

Overall, cane farmers have positive attitudes to calculating fertiliser application rates and handling run off, with a majority (~60% to 90%) believing that their current approaches are the best way to meet their personal goals, to maintain good cash flow, to reduce business risk and to control nutrient loss from their properties. However, when it came to irrigation practices (use of tools), a slightly lower percentage (~50%) of growers in the Burdekin agreed that this practice brought these benefits (although in the Wet Tropics most growers reported this practice as beneficial). Around 50% to 65% of those in the Wet Tropics thought that the practices were the least time-consuming or labour-intensive. By comparison, in the Burdekin, far less agreed (33% to 50%) that the practices were least time-consuming or labour-intensive.

For those growers who had completed a training program specifically designed to facilitate adoption of a specific best management practice (using SIX EASY STEPS to adjust fertiliser application rates), positive attitudes to the behaviours were reported by the majority with regards to both profitability and soil health.

More than half of the cane farmers had applied for grants or financial assistance during the last 5 years, with Reef Rescue being by far the most popular program. Those that received assistance found this to be very useful.

Apx Table 2 Cane summary data

Question/concept	Geographic region					
	Wet Tropics*			Burdekin**		
Question set 1						
Practice	Irrigation practices - use of tools	Calculating fertiliser application rates	Handling run off from rainfall and irrigation	Irrigation practices - use of tools	Calculating fertiliser application rates	Handling run off from rainfall and irrigation
% growers who use irrigation	17%	Not applicable	Not applicable	92%	Not applicable	Not applicable
If irrigate, % using irrigation scheduling tools	60%	Not applicable	Not applicable	91%	Not applicable	Not applicable
% growers who use multiple ways to calculate fertiliser application/handle run off	Not applicable	55%	64%	Not applicable	Nearly 45%	Nearly 47%
Of the cane farmers that have adopted these practice, their perceived benefits of current practices:						
Best way to meet my own personal goals	86%	78%	82%	50%	66%	76%

[9] Statistically significant differences found in the mean responses between the regions for these factors.

Question/concept	Geographic region					
	Wet Tropics*			Burdekin**		
Best way to maintain good cash flow	92%	80%	70%	67%	76%	76%
Best way to reduce business risk	83%	75%	73%	67%	63%	68%
Least time-consuming (or labour intensive)	50%	60%	64%	33%	37%	47%
Most effective way of controlling nutrient loss	83%	80%	83%	50%	76%	84%

Question/concept	Geographic region	
	Wet Tropics*	Burdekin***,**
Question set 2		
Growers were asked whether as a result of participating in project specifically designed to adjust fertiliser application rates to industry standard using six easy steps (6ES), they agreed with the following statements (choices ranging from 1 = strongly disagree to 7 = strongly agree; responses >4 classified as slightly agree or above)		
I think my profitability will improve	Not available	95%
I am happy with the progress I have made	Not available	90%
I think my soil health will improve	Not available	70%
Growers were asked whether they had applied for grants and financial assistance during the last 5 years to enable them to do things on their property:		
% who did apply during the last 5 years	78%	50%
Of those who had applied, the % who had applied for Reef Rescue (the most popular)	88%	84%
Mean usefulness score assigned to Reef Rescue (where 1 = complete waste of time to 7 = extremely useful)	6.4	6.8

Note. *Based upon 248 survey responses from cane farmers in the Wet Tropics during early 2017 (Farr, Eagle, et al., 2017b). **Based upon 38 survey responses from cane farmers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, et al., 2017a). ***Based upon 20 survey responses during June 2017 (Social Marketing @ Griffith, 2017).

A.1.4 Banana summary

The data for banana growers within the Wet Tropics catchment reveals that landholders perceive that a range of best management practices could bring economic benefits to their businesses. More specifically, the adoption of certain practices are expected to increase the production of bananas, and increase the profitability of the enterprise; desirable outcomes that would be expected to encourage adoption of these practices. Whilst the use of the same practices are also expected to increase costs and increase the variability of production (undesirable outcomes that would discourage adoption of these practices), the desirable outcomes are scored higher thus the overall effect is a positive attitude likely to encourage the adoption of these practices. The practice considered to have the largest impact on costs (fertiliser application frequency) was the practice with the lowest adoption rate, at 72%. No significant differences were found between the perceptions of adopters and non-adopters of the practices, other than for fertiliser rate and

fertiliser application method, where adopters reported a higher positive attitude towards the impact on enterprise profitability than non-adopters, and for fertilisation application frequency where non-adopters reported a higher negative attitude towards the impact on production costs than did adopters.

Apx Table.3 Banana summary data

Question/concept	Geographic region Wet Tropics* Mean (min, max)
Question set 2	
Growers were asked to indicate how strongly an economic impact would result from adopting different practices using scale ranged from 1 (large decrease) to 5 (large increase); score of 2.5 is neutral/ no impact.	
Impacts where by a high score indicates a positive attitude towards practice adoption	
Impact on production of bananas averaged across 7 BMP behavioural practices**	3.8 (3.0, 4.2)
Impact on enterprise profitability averaged across 7 BMP behavioural practices**	3.8 (3.3, 4.0)
Impacts whereby a high score indicates a negative attitude towards practice adoption	
Impact on production costs averaged across 7 BMP behavioural practices**	2.9 (2.6, 3.5)
Impact on variability of production averaged across 7 BMP behavioural practices**	3.5 (2.6, 4.2)

Note. *Based upon survey responses from 46 banana growers in the Wet Tropics region during mid 2017 (Cook et al., 2018). **The best management practices (and adoption rates) related to crop removal method (adopted by 78% of respondents), grass or planted fallow crop (83%), crop planting and tillage (76%), living ground cover (87%), fertiliser rates (76%), fertiliser application method (74%) and fertiliser application frequency (72%).

A.2 Perceived behavioural control

A.2.1 Relevant measures adopted in previous research

The questions asked in the studies did not explicitly measure perceived behavioural control with regard to desired land management practices. Instead, they either measured perceived behavioural control over a mix of specific and vaguely-defined/general practices (that generally impact on water quality, such as the calculation of fertiliser application rates), or overland-management decision making in a more general sense. Nonetheless, this data provides some useful insights into the importance of exercising control and feeling effective when it comes to making land-management decisions and practices.

Question set 1

Do landholders currently perceive they have behavioural control over practices on their land?

a) Who makes decisions relating to land-management and farming on your main property? (Farr, Eagle, & Hay, 2017)

Question set 2

Do landholders believe it is important that they have behaviour control over practices on their land?

a) How important is it when making decisions about what to do on your farm/property to be able to make your own decisions about your farm/property? (Farr, Eagle, & Hay, 2017; Farr, Eagle, et al., 2017a, 2017b)
b) How important is it to you to have the ability to control and regulate your own farming practices? (Behaviour Innovation, 2016)

Question set 3

Do landholders perceive any factors restricting their behavioural control over practices on their land?

a) Thinking about your current land management practices landholders were asked how much they agree or disagree with the statement 'I only do this because I am forced to', with a supplementary question of who/what is forcing you? (Farr, Eagle, & Hay, 2017; Farr, Eagle, et al., 2017a, 2017b).

Question set 4

Do landholders feel capable of using the specified practice(s) into the future?

a) Following completion of project, landholders were asked whether they were confident they could continue with their changed practices (Social Marketing @ Griffith, 2017)

A.2.2 Grazing summary

Based upon the data, graziers within the Burdekin catchment do perceive they have control over many aspects of their behaviour regarding the management practices carried out on their lands. However, we do not know whether they perceive similarly high levels of control and self-efficacy over performing specific new farming practices (such as particular actions relating to riparian zone management). Nonetheless, on the basis of the available data on perceived control in general, a majority of graziers perceive that they, together with their family members, are responsible for the decisions made on their land; with few perceiving they are forced to undertake any specific behaviours. A very small percentage (5%) of respondents felt that they only undertake certain practices (i.e., specific methods of spelling of paddocks, adjusting stock levels to paddock conditions or managing stock around waterways) because they are forced to do so, due to factors relating to the natural environment or landscape (e.g., pasture health, weather conditions, drought and sustainability) rather than factors imposed by other parties.

A very high proportion (>90%) believe it to be important that they do have control over these decisions reflecting a strong desire for a high level of autonomy and resistance to mandatory requirements.

Apx Table.4 Grazing summary data

Question/concept	Geographic region
	Burdekin***
Question set 1	

Question/concept	Geographic region Burdekin***
% of respondents responding that this person/people are responsible for land management decisions on their farm/property:	
Landholders entirely or majority responsible	34%
Joint/shared responsibility with other family members (spouse, sibling, parent, child, in-laws, other extended family)	53%
Sub-total of landholder and family members	*87%*
Joint/shared responsibility with someone other than family member (employees, consultants, land owner, Government departments, Townsville City Council, other)	13%
Question set 2	
% responding that it is important to have control/make decisions over their land management practices	97%
Question set 3	
% responding that they only undertake their current land management practices because they are forced to do so* (weighted average across 3 behavioural practices**)	5%

Note. *The factors perceived as 'forcing' behaviours were identified as pasture health, weather conditions, drought, and sustainability. **The practices related to spelling paddocks, adjusting stock levels to paddock conditions, and managing stock around waterways. ***Based upon survey responses from 80 graziers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, & Hay, 2017; Farr, Eagle, et al., 2017a)

A.2.3 Cane summary

Based upon the data, canegrowers within the Wet Tropics and the Burdekin catchments perceive that they have control over many practices carried out on their lands. Whether they perceive similarly high levels of control and self-efficacy over performing particular new farming practices (such as reducing to fertiliser use or nutrient run-off by a specific amount or in a specific manner) cannot be measured from available data.

More specifically, a majority of canegrowers in both regions perceive they are responsible for the decisions made on their land. Less than 10% of respondents perceive that they are forced to undertake any specific behaviours. Those factors that were perceived to 'force' behaviours were generally regulations imposed by other parties.

A very high proportion (>90%) believe it to be important that they do have control over these decisions, reflecting a strong desire for a high level of autonomy. This may have implications with regard to the design and delivery of practice change programs.

Those farmers who have adopted new behaviours as a result of programs expressed confidence that they would be able to continue with these practices in the future, thus expressing perceived self-efficacy with regard to these practices.

Apx Table.5 Cane summary data

Question/concept	Geographic region	
	Wet Tropics* **	**Burdekin**** **
Question set 1		
% of respondents responding that this person/people are responsible for land management decisions on their farm/property		
Landholders entirely or majority responsible for land management decisions on their farm/property	57.1%	59.2%
Joint/shared responsibility with other family members (spouse, sibling, parent, child, in-laws, other extended family)	36.6%	29.7%
Sub-total of landholder and family members	*93.7%*	*88.9%*
Joint/shared responsibility with someone other than family member (supervisor, advisor, farm management/leadership team, partner, owner)	6.3%	11.1%
Question set 2		
% responding that it is important to have control/make decisions over their land management practices	98.3%	93.0%
Question set 3		
% responding that they only undertake their current land management practices because they are forced to do so* (weighted average across 3 behavioural practices**)	4.7%	9.7%
Question set 4		
Growers were asked whether following completion of project specifically designed to adjust fertiliser application rates to industry standard using SIX EASY STEPS (6ES), they agreed with the following statements (choices ranging from 1 = strongly disagree to 7 = strongly agree; responses >4 classified as slightly agree or above)		
I am confident I can continue using 6ES to calculate my cane nutrient requirements	Not available	88.3%
I am able to continue using 6ES on my own	Not available	72.7%
I can overcome obstacles faced in using 6ES on my own	Not available	63.3%

Note. *In the Wet Tropics, the factors perceived as 'forcing' behaviours were identified as government, state government, government regulation, EHP, bureaucrats, reef compliance, reef regulations, legislation and Mother Nature, whilst in the Burdekin one respondent felt that government was forcing them to conduct this behaviour with no other factors noted. **The practices related to scheduling irrigation, calculating fertiliser application rates, and handling runoff. ***Wet Tropics data is based upon two studies, comprising 248 survey responses during early 2017 (Farr, Eagle, et al., 2017b) and 48 survey responses during 2016 (Behaviour Innovation, 2016). ****Burdekin data is based upon a study comprising 54 survey responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a) and a study comprising 14 survey responses during 2017 (NQ Dry Tropics, 2017) and upon 20 survey responses during June 2017 (Social Marketing @ Griffith, 2017).

A.3 Perceived barriers (control beliefs)

A.3.1 Relevant measures adopted in previous research

The studies cover vaguely-defined practices for cane and banana growers, relating to practices designed to improve water quality. No such information was available relating to graziers. Thus,

these studies provide limited information on perceptions of barriers preventing the adoption of desired practices, and not necessarily any information on specific barriers relating to specific desired practices (for example, considering whether fertiliser application rates are calculated rather than whether they are calculated and applied in a particular manner).

A small number of the questions asked in our sample studies sought to explicitly measure perceived barriers to adoption of new land management practices.

Question set 1

Do landholders perceive any barriers preventing the adoption of desired practices on their land?

a) What barriers do farmers perceive to changing their behaviours to adopt best management practices? (NQ Dry Tropics, 2017)
b) Is negative public messaging seen as a barrier to change? (Behaviour Innovation, 2016)
c) What are the key characteristics of best management practices that are perceived to act as a constraint (or barrier) to the adoption of the practice, or alternately to encourage adoption (Cook et al., 2018).

A.3.2 Cane summary

Whilst very limited data is available, a perceived culture of blame (whereby growers perceive cane farmers are blamed and unfairly targeted)was perceived by 64% of the Burdekin sample to be a barrier to adopting desired practices.

Other identified barriers to the adoption of best management practices (fitting the definition above) include barriers due to money or to current machinery/equipment. More than one third of respondents perceived time constraints as impacting their control over adoption of best practices.

Apx Table Error! No text of specified style in document.**.6 Cane summary data**

Question/concept	**Geographic region**	
	Wet Tropics*	**Burdekin****
Question set 1		
When asked to assign a score to identify how much of a barrier to change is negative public messaging about cane farming practices? (Not at all =1, A little bit of an issue=2, A big issue =3, A major issue =4)		
Mean score assigned	2.58	Not available
When asked to identify barriers to adoption of best management practices		
% identifying barriers relating to money	Not available	21.4%
% identifying barriers relating to equipment	Not available	28.6%
% identifying barriers relating to the culture of blame	Not available	64.3%
% identifying time constraints as a barrier to adopting best management practices	Not available	35.7%
% identifying one (or more) of the barriers to behaviour change listed above	*Not available*	*85.7%*

Note. *Wet Tropics data is based upon 48 survey responses during 2016 (Behaviour Innovation, 2016) **Burdekin data is based upon 14 survey responses during 2017 (NQ Dry Tropics, 2017).

A.3.3 Banana summary

Based upon the data, banana growers within the Wet Tropics catchment do not perceive strong barriers preventing the adoption of desired land management practices relating to improved water quality. More specifically, few strong constraints (or barriers) to behaviour change were reported, with practice characteristics on average being scored as being in the range neutral (score of 3 out of 5) to mildly encouraging adoption (score of 2 out of 5) of the desired practice.

The practice characteristic perceived as the highest barrier to adoption was an understanding that 'high capital investment required', perceived to be particularly relevant to practices relating to crop planting and tillage, and to fertiliser application methods. The average score for this constraint was 2.9, thus overall this is not viewed as a barrier but given a neutral rating; however it was perceived as a barrier by some growers as the maximum score assigned was 4 out of 5. Furthermore, responses between adopters and non-adopters of the practices were compared. For the constraint described as 'contractors needed to implement change', non-adopters of the fertiliser rate practice scored this as a significantly higher barrier than did adopters of the practice. For the constraint described as 'does not fit with my current farming systems', non-adopters of the practices relating to crop removal, fertiliser rate and fertiliser application method scored this as a significantly higher barrier than did adopters of the practices.

The final practice characteristic perceived by some as likely to act as a barrier was a belief that the practice 'requires new skills', particularly relating to crop planting and tillage practices. No significant differences were found between the perceptions of adopters and non-adopters of this practice.

Apx Table.7 Banana summary data

Question/concept	Geographic region Wet Tropics** Mean (min, max)
Question set 1	
Mean score assigned in response to growers being asked to indicate how strongly they agreed/disagreed with statements describing characteristics of 7 different practices* using a scale ranged from 1 (strongly disagree) to 5 (strongly agree); statements phrased such that higher scores reflect higher barriers to adoption and lower scores reflect encouraging practice adoption; hence midpoint score of 3.	
Average score reported for constraint 'high capital investment required'	2.9 (2.0, 4.0)
Average score reported for constraint ' contractors needed to implement change'	2.3 (1.8, 3.0)
Average score reported for constraint 'does not fit with my current farming system'	2.2 (1.9, 2.5)
Average score reported for constraint 'too much time required'	2.0 (1.0, 2.5)
Average score reported for constraint ' requires new skills'	2.7 (2.2, 3.6)
Average score reported for constraint 'not easy to trial'	2.1 (1.9, 2.6)
Average scores for the six possible barriers listed above	*2.4 (1.0, 4.0)*

Note. *Practices related to crop removal method, grass or planted fallow crop, crop planting and tillage, living ground cover, fertiliser rates, fertiliser application method and fertiliser application frequency. **Based upon survey responses from 46 banana growers in the Wet Tropics region during mid 2017 (Cook et al., 2018).

A.4 Motivation

A.4.1 Relevant measures adopted in previous research

The questions asked in our sample studies did not explicitly measure the motivations underpinning the adoption of specific new land management practices. Instead, they approached this theme from a number of different aspects. Firstly, considering the landholder's personal goals and aspirations for the property (which may provide insights into the overarching motivations underpinning the landholders land management activities). Secondly, the importance of various factors when making land-management decisions on the property (which may provide some useful insights into the relative motivational impact of different behavioural drivers). Thirdly, what were landholders hoping to achieve when applying for grants and funding (indicating the motivation for their application).

Question set 1

What are the landholder's personal goals and aspirations?

a) What are the two most important things you hope to achieve (your goals) for your farm/property? (Farr, Eagle, et al., 2017a, 2017b)

Question set 2

What do landholders perceive as important when making land-management decisions?

a) How important are each of the following [21 specified factors including internal (e.g. leaving land in better condition) and external (e.g. maximising farm profits)] when making decisions about what to do on your farm/property? (Farr, Eagle, & Hay, 2017; Farr, Eagle, et al., 2017a, 2017b)
b) Thinking about making change to your farming practices, how influential would you rate each of the following [8 specified factors including internal (e.g. access to more knowledge and extension) and external (e.g. improving your productivity)]? (Behaviour Innovation, 2016)

Question set 3

What was the most important thing you hoped to achieve with this grant? (Farr, Eagle, et al., 2017a, 2017b).

A.4.2 Grazing summary

Based upon the data available, it appears that graziers within the Burdekin are motivated by a range of different internal and external factors. Whilst motivations regarding specific new farming practices (such as particular actions relating to riparian zone management) were not assessed, a minority of graziers are motivated by the desire to operate their farms in a sustainable (~40%) and profitable (~22%) manner and to be able to pass the property on in a healthy condition to future generations (~19%).

Apx Table Error! No text of specified style in document.**.8 Grazing summary data**

Question/concept	Geographic region Burdekin*
Question set 1	
% of respondents who reported the following as one of their two main personal goals (Only goals receiving > 15% of responses for either region (Wet Tropics or Burdekin) or industry (grazing or cane) are reported):	
Sustainability (internal)	39.7%
Profitability (external)	21.5%
Pass on a healthy property to future generation (internal)	18.5%
Improved groundcover/pastures (internal)	18.3%
Financial security (external)	13.2%
Productivity (external)	11.7%
Question set 2	
Mean score assigned in response to: How important are each of the following when making decisions about what to do on your farm/property? where 1 = extremely unimportant, 7 = extremely important. (Categories with mean scores > 6 or <4 for either industry (cane/grazing) or region (Wet Tropics/Burdekin) reported)	
>6 in either region or industry	
Leaving the land/farm in better condition (internal)	6.66
Maintaining/improving water supplies & storages (internal)	6.58
Physical & mental health of family (internal)	6.50
Being able to make your own decisions (internal)	6.44
Minimising sediment runoff and/or nutrient losses (internal)	6.34
Minimising risk (external)	6.32
Maximising farm profits (external)	6.29
Keeping a stable cash flow (external)	6.18
Spending face to face time with family & friends (internal)	5.95
Servicing debt (external)	5.95
Helping to safeguard local waterways (internal)	5.92
Keeping farm costs low (external)	5.92
Learning about and testing news ways of doing things on your farm/property (internal)	5.89
Maintaining good relations with other farmers/graziers in the local area (internal)	5.71
Helping to safeguard the GBR (internal)	5.39
<4 in either region or industry	
Having efforts recognised by the wider community (external)	3.66
Question set 3	
What were the most important things farmers were hoping to achieve with grant funding? (No data was provided on % of farmers indicating response, the report merely listed the main factors noted)	

Question/concept	Geographic region
	Burdekin*
Water quality improvement	Yes
Soil health improvement	Yes
Decrease in farm run off	Yes
Sustainability	Yes
Spreading stocking pressures over property for better grazing	Yes
Erosion control	Yes
Purchase of implements and tools	Not noted
Practice change	Yes

Note. *This summary is based upon survey responses from 80 graziers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, & Hay, 2017; Farr, Eagle, et al., 2017a).

A.4.3 Cane summary

Based upon the data, it appears that cane farmers within the Wet Tropics and the Burdekin are motivated by a range of different internal and external factors. Whilst motivations regarding specific new farming practices (such as particular actions relating to reducing fertiliser use or nutrient run-off) were not assessed, we can see that cane farmers are motivated most strongly by the desire to operate their farms in a sustainable manner and by the productivity and profitability of their farms.

Apx Table.9 Cane summary data

Question/concept	Geographic region	
	Wet Tropics*	Burdekin**
Question set 1		
% of respondents who reported the following as one of their two main personal goals (Only goals receiving responses >15% for either region (Wet Tropics or Burdekin) or industry (grazing or cane) are reported):		
Sustainability (internal)	29.3%	37.0%
Productivity/Higher sugar (external)	28.3%	31.2%
Profitability/Income (external)	27.7%	22.5%
Financial security (external)	19.7%	19.5%
Pass on a healthy property to future generation/viable for future generations/farm succession (internal)	20.5%	12.5%
Improved groundcover/pastures (internal)	0.0%	2.6%
Question set 2		
Mean score assigned in response to: How important are each of the following when making decisions about what to do on your farm/property? where 1 = extremely unimportant, 7 = extremely important. (Categories with mean scores > 6 reported or <4 for either region or industry are reported)		
>6 in either region or industry		
Leaving the land/farm in better condition (internal)	6.59	6.56

Question/concept	Geographic region	
	Wet Tropics*	**Burdekin****
Being able to make your own decisions (internal)	6.59	6.47
Maximising farm profits (external)	6.53	6.44
Keeping farm costs low (external)	6.43	6.44
Maintaining/improving water supplies & storages (internal)	5.43	6.43
Minimising risk (external)	6.26	6.42
Minimising sediment runoff and/or nutrient losses (internal)	6.55	6.37
Helping to safeguard local waterways (internal)	6.42	6.35
Helping to safeguard the GBR (internal)	6.40	6.32
Keeping a stable cash flow (external)	6.48	6.30
Physical & mental health of family (internal)	6.59	6.17
Servicing debt (external)	6.09	6.16
Learning about and testing news ways of doing things on your farm/property (internal)	6.23	6.14
Spending face to face time with family & friends (internal)	6.19	5.74
Maintaining good relations with other farmers/graziers in the local area (internal)	6.13	5.42
<4 in either region or industry		
Having efforts recognised by the wider community (external)	4.64	4.49
Mean score assigned in response to: How influential are each of the following when thinking about making change to your farming practices? where 1 = not at all influential, 5 = extremely influential.		
Improving your productivity (external)	4.59	Not available
Access to more knowledge and extension (internal)	4.13	Not available
Public appreciation for the role of the cane industry in protecting the reef	3.97	Not available
Appreciation for what you have already done	3.80	Not available
Knowing that other farmers in your district are doing something differently	3.78	Not available
Government Regulations	3.65	Not available
Knowing the cane industry is not the only target for change (external)	3.40	Not available
Pressure from Government (external)	3.35	Not available
Question set 3		
What were the most important things farmers were hoping to achieve with grant funding? (No data was provided on % of farmers indicating response, the report merely listed the main factors noted)		
Water quality improvement	Not noted	Yes
Decrease in use of nitrogen	Not noted	Yes
Sustainability	Not noted	Yes
Profitability	Not noted	Yes
Decrease in costs	Not noted	Yes
Erosion control	Not noted	Yes

Question/concept	Geographic region	
	Wet Tropics*	Burdekin**
Purchase of implements and tools	Yes	Yes
Practice change	Yes	Yes

Note. *Wet Tropics data is based upon two studies, comprising 248 survey responses during early 2017 (Farr, Eagle, et al., 2017b) and 48 survey responses during 2016 (Behaviour Innovation, 2016). **Burdekin data is based upon a study comprising 54 survey responses during late 2016/early 2017 (Farr, Eagle, et al., 2017a).

A.5 Behaviours (past and future)

A.5.1 Relevant measures adopted in previous research

A number of the questions asked in the studies sought to identify whether the landholders were currently using specified desired practices (either as result of a particular program or not), whilst other questions identified more generally the types of practices that were being used. The studies referred to cover a mix of specific and more general practices relating to improved water quality.

Question set 1

Do landholders explicitly use the specified practice/practices?

a) Following participation in a project [specifically designed to enable cane farmers to adjust fertiliser application rates to industry standard using SIX EASY STEPS] landholders were asked to agree or disagree that they have changed farming practices in specified ways (Social Marketing @ Griffith, 2017)
b) Which of the following [7 specified] best management practices do you currently use? (Cook et al., 2018)

Question set 2

Do landholders currently use practices that fall within specified broad categories, and are these behaviours likely to change in the future?

a) Landholders were asked whether they had adopted behaviours within each broad category, and whether they intended to use the same practices in the following year (Farr, Eagle, et al., 2017a, 2017b)
b) When asked about benefits and barriers to practice change, some landholders volunteered responses regarding their current practice behaviours, and their likelihood of changing these current practice behaviours to desired practices (NQ Dry Tropics, 2017).

A.5.2 Grazing summary

The available data informs us that the majority of graziers have adopted practices that can broadly be classified of the type that may improve water quality, and that within each category there is a broad variety of different specific practices, some of which may be desired best practices.

The data also clearly demonstrates that a large majority (>90%) are intending to continue to use the same practices in the next year. The proportion of these who have currently adopted desired best practice, or not, is not available from the study.

Apx Table Error! No text of specified style in document.**10 Grazing summary data**

Question/concept	Geographic region		
	Burdekin*		
Question set 2			
Specific practices that landholders were questioned about	Spelling paddocks during most recent wet period	Adjusting stock numbers to paddock conditions	Stock management around waterways
% graziers currently adopting category of practice	72.0%	96.3%	81.5%
These categories can be sub-divided as follows:			
All of paddock spelled	20.5%	Not applicable	Not applicable
About ¾ of paddock spelled	12.8%	Not applicable	Not applicable
About ½ of paddock spelled	15.4%	Not applicable	Not applicable
Less than ½ of of paddock spelled	51.3%	Not applicable	Not applicable
Proportion with an end of season target for pasture condition	Not applicable	91.0%	Not applicable
Prevents cattle accessing some or all waterways at all times	Not applicable	Not applicable	35.2%
Prevents cattle accessing some or all waterways during wet season	Not applicable	Not applicable	29.6%
Manages cattle around waterways in some other	Not applicable	Not applicable	16.7%
Does not prevent cattle accessing waterways	Not applicable	Not applicable	18.5%
Proportion intending to use the same practices in following year	92%	94%	94%

Note. *Based upon survey responses from 80 graziers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, et al., 2017a).

A.5.3 Cane summary

From the limited data available, completion of a practice change program does result in adoption of desired farming practices by a majority of participants.

The available data also informs us that the majority of cane farmers have adopted practices that can broadly be classified of the type that may improve water quality, and that within each category there is a broad variety of different specific practices, some of which may be desired best practices.

The data clearly demonstrates that a large majority (>90% where data is available) are not intending to change from their current behaviours in the next year.

Apx Table 11 Cane summary data

Question/concept	Geographic region	
	Wet Tropics	Burdekin*
Question set 1		
Growers were asked whether as a result of participating in project specifically designed to adjust fertiliser application rates to industry standard using SIX EASY STEPS (6ES), they agreed with the following statements (choices ranging from 1 = strongly disagree to 7 = strongly agree; responses >4 classified as slightly agree or above)		
I have changed my farming practices to control nitrogen losses	Not available	94.7%
I have changed irrigation scheduling	Not available	80.0%
My weed management timing has changed	Not available	45.0%
Question set 2		
% of landholders volunteering that their current practices do not meet best practice	Not available	21%
% of landholders volunteering that their current practices do meet best practice in at least one aspect, or claiming they are doing all the they can to contribute to wetland health	Not available	64%
% of landholders considering specific practice change	Not available	7%

Question/concept	Geographic region					
	Wet Tropics**			Burdekin***		
Question 3						
Specific practices that landholders were questioned about	Irrigation practices - use of tools	Calculating fertiliser application rates	Handling run off from rainfall and irrigation	Irrigation practices - use of tools	Calculating fertiliser application rates	Handling run off from rainfall and irrigation
% growers who use irrigation	16.5%	Not applicable	Not applicable	92.1%	Not applicable	Not applicable
If irrigate, % using irrigation scheduling tools	60.0%	Not applicable	Not applicable	91.2%	Not applicable	Not applicable
% growers who use multiple ways to calculate fertiliser application/handle run off	Not applicable	55%	64%	Not applicable	Nearly 45%	Nearly 47%
% growers using practice, where current practices are A or B using ABCD framework	0%	76.7%	2.5%	35.3%	73.7%	47.4%
Proportion intending to use the same practices in following year	95%	Not available	"Nearly all" (exact % not provided)	94%	Not available	"Virtually all" (exact % not provided)

Note. *Based upon 20 survey responses during June 2017 (Social Marketing @ Griffith, 2017) and upon 14 survey responses during 2017 (NQ Dry Tropics, 2017). **Based upon 248 survey responses from cane farmers in the Wet Tropics during early 2017 (Farr, Eagle, et al., 2017b). ***Based upon 38 survey responses from cane farmers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, et al., 2017a).

A.5.4 Banana summary

Based upon data available the majority of banana growers report that they already operate best management practices; lowest adoption rates are seen with regard to practices related to fertiliser use.

Apx Table 12 Banana summary data

Question/concept	Geographic region Wet Tropics* % adopted
Question set 1	
Adoption rates for each of 7 best management practices were identified:	
Crop removal method – crop removed by treating with herbicide and plants left to break down in the row area before cultivation	78%
Grass or planted fallow crop – grass or planted fallow crop grown between banana crop cycles for at least 12 months	83%
Crop planting and tillage – crop planted in permanent beds, row area receives minimum tillable necessary	76%
Living ground cover – at least 60% achieved in areas such as inter-row space and headlands	87%
Fertiliser rates – based on recommended rates supported by leaf and soil testing on every block and yield monitoring; program revised annually, and checked to ensure targets are updated and applied	76%
Fertiliser application method – fertigation or combination of fertigation and banded surface applications, dependent on weather conditions.	74%
Fertiliser application frequency – applied fortnightly during high growth periods, reduced in low growth periods and when weather conditions mean this is not possible	72%

Note. * Based upon survey responses from 46 banana growers in the Wet Tropics region during mid 2017 (Cook et al., 2018).

A.6 Group norms

A.6.1 Relevant measures adopted in previous research

The studies explored this indicator from a number of perspectives. Firstly, how the current practices of landholders compare with those adopted by other landholders, indicating whether landholders perceived that current behaviours complied with a group norm. Secondly, how influential the behaviours of others were in encouraging landholders to change their own behaviours, indicating whether being outside the norm may influence behaviour change. Thirdly, whether they feel part of growers community and want to connect to others, which may inform as to the likely importance of group norms.

Question set 1

Seeking comparisons between current behaviours and those of other landholders:

a) Landholders perceptions with regards to whether their current practices are those practices that they believe are used by the farmers they respect most (Farr, Eagle, & Hay, 2017; Farr, Eagle, et al., 2017a, 2017b)

Question set 2

Seeking information with regard to the influence of the behaviour of others on potential future behaviour change:

a) Thinking about making change to your farming practices, how influential would you rate (i) knowing that other farmers in your district are doing something differently (ii) public appreciation for the role of the cane industry in protecting the reef (Behaviour Innovation, 2016)
b) When making decisions about what to do on the farm/property, how important is it to have your efforts recognised by the wider community? (Farr, Eagle, & Hay, 2017; Farr, Eagle, et al., 2017a, 2017b)

Question set 3

Seeking information on their social connectedness within the community of landholders

a) Whether being a cane farmer is important to their sense of who they are, whether they take pride in being a grower, whether they would like to be better connected to other growers (Behaviour Innovation, 2016).

A.6.2 Grazing summary

Based upon the data available, around one third to over a half of graziers believe their current practices are also adopted by the farmers they respect the most, with the actual proportion varying (~35% to 57%) depending on the broad category of practice being considered.

A small proportion (<5%) feel it is important to have efforts recognised by the wider community, suggesting wider community group norms are not perceived to be important to graziers.

Apx Table.13 Grazing summary data

Question/concept	Geographic region Burdekin*
Question set 1	
When asked about landholder current practices within the categories set out below, % responding that their current practices are those practices that they believe are used by the farmers they respect most	
Spelling paddocks during most recent wet period	46.3%
Adjusting stock numbers to paddock conditions	35.2%
Stock management around waterways	57.4%
Question set 2	
When making decisions about what to do on the farm/property % responding that it is important to have your efforts recognised by the wider community	4.8%

Note. *This summary is based upon survey responses from 80 graziers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, & Hay, 2017; Farr, Eagle, et al., 2017a).

A.6.3 Cane summary

Based upon the data available, around half of cane farmers believe their current practices are those adopted by the farmers they most respect, with the actual proportion varying slightly (~39% to 56%), depending on the category of practice being considered.

Knowing other farmers are doing something different, and receiving public appreciation for efforts in protecting the reef are considered reasonably or very influential when thinking about changing current practices, although around 15% agree that it is important to have one's individual farming efforts recognised by the wider community..

On average, cane farmers do feel part of a group, with being a grower forming an important part of their identity and being a source of pride. Furthermore cane farmers would like to be better connected to other growers which could further strengthen the group ties.

Apx Table.14 Cane summary data

Question/concept	Geographic region	
	Wet Tropics*	Burdekin**
Question set 1		
When asked about landholder current practices within the categories set out below, % responding that their current practices are those practices that they believe are used by the farmers they respect most		
Irrigation practices - use of tools	38.5%	50.0%
Calculating fertiliser application rates	45.7%	55.3%
Handling run off from rainfall and irrigation	55.8%	47.4%
Question set 2		
Thinking about making change to your farming practices, how influential would you rate each of the following? (Mean score, where 1=Not at all influential, 2=A little bit influential, 3=Reasonably influential, 4=Very influential, 5=Extremely influential)		
Knowing that other farmers in your district are doing something differently	3.78	Not available
Public appreciation for the role of the cane industry in protecting the reef	3.97	Not available
When making decisions about what to do on the farm/property % responding that it is important to have your efforts recognised by the wider community	14.7%	18.6%
Question set 3		
Being a cane grower is important to my sense of 'who I am' (Mean score where Not at all =1, A little bit=2, A lot=3)	2.66	Not available
% who responded 'a lot' to the above question	*70.7%*	*Not available*
% who answered 'yes' when asked if they take great pride in being a Queensland cane grower	97.5%	Not available
% who answered 'yes' when asked if they would like to be better connected with growers in their area	66.7%	Not available

Note. *Based upon 248 survey responses from cane farmers in the Wet Tropics during early 2017 (Farr, Eagle, et al., 2017b) and 48 survey responses during 2016 (Behaviour Innovation, 2016) **Based upon 38 survey responses from cane farmers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, et al., 2017a).

A.7 Trust

A.7.1 Relevant measures adopted in previous research

Landholders were asked about trust from two different perspectives; firstly in regard to whom they trusted regarding the land management practices they currently use, and secondly in regard to whom they trust when considering changes to their land management practices.

Question set 1

Who do landholders most trust for advice regarding their current land management practices?

a) Landholders were asked who they trusted for advice when applying their current categories of practices (Farr, Eagle, & Hay, 2017; Farr, Eagle, et al., 2017a, 2017b)

Question set 2

Who do landholders most trust for advice when considering making changes to their current land management practices?

a) Landholders were asked, with respect to making change to your farming practices, how much do they trust each of the following groups? (Behaviour Innovation, 2016)

A.7.2 Grazing summary

Based on the data available, graziers most trust the advice they receive from family who are also graziers, other graziers, and 'other'. The 'other' category includes a wide range of different types of people and organisation, including themselves and their own experience, manager of the property, grazing BMPs, education programs, other graziers who are achieving/successful/pro-active, people who are achieving what we want, private consultants, trial results, and Townsville city council.

Apx Table 15 Grazing summary data

Question/concept	**Geographic region**		
	Burdekin*		
Question set 1			
Practice	Spelling paddocks during most recent wet period	Adjusting stock numbers to paddock conditions	Stock management around waterways
Graziers were asked to rank the importance of whose advice they follow most when deciding how to apply their current management practice. Ranked on a scale where 1= very important and 12= very unimportant. % ranking the importance of advice as either 1 or 2 as follows:			
Family who are also graziers	41%	40%	41%
Other graziers	37%	33%	33%
Non-farming family & friends	2%	2%	2%
Agforce	4%	0%	0%
QLD Farmers Federation	2%	0%	0%

Question/concept	Geographic region		
	Burdekin*		
Meat & Livestock Australia	6%	4%	4%
Private Agronomists	4%	2%	2%
Extension offices	12%	8%	8%
People from NQDT	25%	19%	29%
Landcare	8%	6%	10%
Researchers	4%	10%	12%
People from government departments	6%	10%	4%
Other	33%	33%	35%
Number of graziers responding to question	51	52	49

Note. *This summary is based upon survey responses from 80 graziers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, et al., 2017a)

A.7.3 Cane summary

Based on the data, cane farmers most trust the advice they receive from industry extension offices, private agronomists, family who are also cane farmers, other canegrowers and 'others'. The 'other' category includes a wide range of different types of people and organisation, including soil tests, consultants, trial results, those selling fertiliser, make up their own minds, BMP groups, agribusinesses, soil analysts, Cairns regional council, drainage engineers.

When considering changing practices, those most trusted are productivity service groups, CANEGROWERS association, and other growers.

Very little trust is placed in advice from people within government departments, with regard to both current practices and potential changes in practices.

Apx Table Error! No text of specified style in document. **16 Cane summary data**

Question/concept	Geographic region					
	Wet Tropics*			Burdekin**		
Question set 1						
Practice	Irrigation practices - use of tools	Calculating fertiliser application rates	Handling run off from rainfall and irrigation	Irrigation practices - use of tools	Calculating fertiliser application rates	Handling run off from rainfall and irrigation
Growers were asked to rank the importance of whose advice they follow most when deciding how to apply their current management practice. Ranked on a scale where 1= very important and 12= very unimportant. % ranking the importance of advice a either 1 or 2 as follows:						
Family who are also cane farmers	5%	18%	34%	17%	16%	11%
Other cane farmers	10%	14%	23%	33%	3%	11%

Question/concept	Geographic region					
	Wet Tropics*			Burdekin**		
Canegrowers organisation	5%	8%	28%	0%	0%	3%
Regional cane association	0%	0%	0%	0%	3%	0%
People from NQDT/Terrain	0%	1%	12%	0%	5%	20%
Private Agronomists	0%	37%	4%	33%	58%	46%
Landcare	5%	1%	16%	0%	0%	0%
Researchers	15%	22%	21%	17%	13%	11%
Industry extension officers	55%	85%	78%	33%	45%	34%
Other extension officers	0%	13%	8%	0%	8%	6%
People from government departments	0%	1%	2%	0%	0%	3%
Other	40%	30%	36%	0%	16%	26%
Number of growers responding to question	20	181	120	6	38	35

Question	Geographic region	
	Wet Tropics***	Burdekin****
Question set 2		
Growers were asked, with respect to making change to your farming practices, how much do they trust each of the following groups? (1=No trust at all, 2=Trust very little, 3=Neutral, 4=Trust, 5=Trust a lot). Mean scores:		
QLD Government	1.48	Not available
Australian Government	2.00	Not available
National Resource Management (NRM) groups	2.66	Not available
CANEGROWERS organisation	3.98	Not available
The media	1.82	Not available
Scientists/researchers	2.95	Not available
Other growers	3.95	Not available
Mill operators	2.40	Not available
Fertiliser Suppliers	3.24	Not available
Productivity Services Groups	4.24	Not available
Question set 2		
% of landholders volunteering that they feel trust towards extension officers/NRM groups (NQDT and/or BBIFMAC) when considering new practices	Not available	43%

Note. *Based upon 248 survey responses from cane farmers in the Wet Tropics during early 2017 (Farr, Eagle, et al., 2017b). **Based upon 38 survey responses from cane farmers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, et al., 2017a). ***Based upon 48 survey responses during 2016 (Behaviour Innovation, 2016). ****Based upon 14 survey responses during 2017 (NQ Dry Tropics, 2017).

A.8 Cultural norms

A.8.1 Relevant measures adopted in previous research

Within the studies, landholders were asked questions regarding innovation and sharing new ideas with owners within their farming community, and about their own desires to learn about and implement new techniques and practices. We note that these measures provide a limited assessment of what cultural norms is supposed to represent.

Question set 1

Landholders were asked about the importance of sharing new ideas with others when making decisions about what to do on the farm / property (Farr, Eagle, & Hay, 2017).

Question set 2

Landholders were asked about the level of innovation in their industry, and in their own practices (Behaviour Innovation, 2016).

Question set 3

Landholders were asked about their desires to learn new techniques and be able to improve their own practices (Behaviour Innovation, 2016; Farr, Eagle, & Hay, 2017).

A.8.2 Grazing summary

From the available data, graziers believe it is important to share new ideas with others, and that it is important for them to learn about, and test, new land management practices.

Apx Table 17 Grazing summary data

Question/concept	Geographic region
	Burdekin*
Question set 1	
How important is it to share new ideas with others when making decisions on your farm/property? where 1 = extremely unimportant, 7 = extremely important: mean score	5.35
Question set 3	
How important is it to learn about and test new ways of doing things when making decisions on your farm/property? where 1 = extremely unimportant, 7 = extremely important: mean score	5.89

Note. *This summary is based upon survey responses from 80 graziers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, & Hay, 2017).

A.8.3 Cane summary

From the available data, cane farmers believe it is important to share new ideas with others. They believe the sugar cane industry is an innovative industry, and innovation within their community is very important to them.

It is important for cane farmers to learn about, and test, new land management practices, and they express a desire to learn new techniques and be able to improve their practices.

Apx Table 18 Cane summary data

Question/concept	Geographic region	
	Wet Tropics*	Burdekin**
Question set 1		
How important is it to share new ideas with others when making decisions on your farm/property? where 1 = extremely unimportant, 7 = extremely important: mean score	5.97	5.60
Question set 2		
How important is innovation within the farming community to you? (Where 1 = Very unimportant, 2 = Unimportant, 3 = Neither important nor unimportant, 4 = Important, 5 = Very Important) Mean score	4.60	Not available
Compared to other growers, how innovative are your farming practices? (Much less innovative=1, Less innovative=2, About the same=3, More innovative=4, Much more Innovative=5) Mean score	4.10	Not available
How innovative do you think the QLD sugarcane industry is? (Not at all innovative =1, A little bit innovative=2, Neither innovative or uninnovative=3, Reasonably innovative=4, Very innovative=5) Mean score	4.02	Not available
% agreeing with the statement that they wish the cane industry was better recognised for how innovative it is	95.4%	Not available
Question set 3		
How important is it to learn about and test new ways of doing things when making decisions on your farm/property? where 1 = extremely unimportant, 7 = extremely important: mean score	6.23	6.14
'I have a desire to learn about new farming techniques and improve my practices.' (Not true at all about me=1, A little bit true=2, I'm indifferent =3, True about me=4, Very true about me =5) Mean score	4.59	Not available

Note. *Based upon 248 survey responses from cane farmers in the Wet Tropics during early 2017 (Farr, Eagle, & Hay, 2017) and 48 survey responses during 2016 (Behaviour Innovation, 2016) **Based upon 54 survey responses from cane farmers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, & Hay, 2017).

A.9 Cultural artefacts

A.9.1 Relevant measures adopted in previous research

Limited data on cultural artefacts was available from previous studies. At best, these studies asked whether landholders had participated in programs and extension activities in the recent past; these studies covered a wide range of different programs and activities. We note that this data provides a very small assessment of what cultural artefacts should represent.

Question set 1

Have landholders previously participated in workshops, training programs, and extension activities?

a) Landholders were specifically asked whether they had participated in such programs within the last 5 years, and whether these were useful or not (Farr, Eagle, et al., 2017a, 2017b).
b) Landholders were asked whether their networks have increased as a result of their participation in programs (Social Marketing @ Griffith, 2017).

A.9.2 Grazing summary

Based on the available data, almost half of all graziers have participated in workshops, training programs and extension activities within the last 5 years. The specific programs that had been most widely participated in were Holistic Management (13.8%) and BMP (10.34%); participation rates reported by respondents for other programs were all <10%. These most popular programs were scored as useful by the attendees. However, a number of programs with small numbers of participants were scored as extremely useful (scoring 7 out of 7), being biosecurity, rural mental health, beef up forums, breed plan and cost efficient and returns of production feeding.

Apx Table 19 Grazing summary data

Question/concept	Geographic region Burdekin*
Question set 1	
% that had participated in workshops, training programs and extension activities in the last 5 years	48.3%
For programs attended by >10% of respondents, mean score for usefulness of program where 1=waste of time and 7=extremely useful.	
Holistic management	5.63
BMP	4.83

Note. *This summary is based upon survey responses from 58 graziers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, et al., 2017a).

A.9.3 Cane summary

Based on the available data, over half of all cane growers in the Burdekin and almost all (>90%) of those in the Wet Tropics have participated in workshops, training programs and extension activities within the last 5 years.

Within the Burdekin, the specific programs that had been most widely participated in were 6 easy steps (22%) and Smartcane BMP (18.6%); participation rates reported by respondents for other programs were all <10%. These most popular programs were scored as useful by the attendees. However, a number of programs with small numbers of participants were scored as extremely useful (scoring 7 out of 7), being Project Catalyst, Reef run-off workshops, soil biology & health, Herbicide application, Reef Rescue nitrogen trial, and Water Quality grant. Within the Wet Tropics, the specific programs that had been most widely participated in were AusChem (15.5%), Integrated weed management (WTSIP) (12.1%), Nutrient Management (30.1%), and Smartcane BMP (17.2%); participation rates reported by respondents for other programs were all <10%. These most popular programs were scored as useful to very useful by the attendees. However, a

number of programs with small numbers of participants were scored as extremely useful (scoring 7 out of 7), being Digging Deeper, Project Catalyst, Regen Ag, Diploma of Agriculture, and Land Management Terrain.

A large proportion (85%) of participants in one specific program (nutrient management) reported that participation had increased their network.

Apx Table 20 Cane summary data

Question/concept	Geographic region	
	Wet Tropics*	Burdekin**
Question set 1		
% that had participated in workshops, training programs and extension activities in the last 5 years	91.4%	58.5%
For programs attended by >10% of respondents, mean score for usefulness of program where 1=waste of time and 7=extremely useful.		
AusChem	6.13	No responses
Integrated weed management	6.08	No responses
Nutrient management	6.02	No responses
6 easy steps	No responses	5.00
Smartcane BMP	5.76	4.45
% of growers reporting that their network has increased as a result of participation in program	Not available	85%

Note. *Based upon 246 survey responses from cane farmers in the Wet Tropics during early 2017 (Farr, Eagle, et al., 2017b). **Based upon 41 survey responses from cane farmers in the Burdekin region during late 2016/early 2017 (Farr, Eagle, et al., 2017a) and 20 responses during 2017 (Social Marketing @ Griffith, 2017).

CONTACT US

t 1300 363 400
+61 3 9545 2176
e csiroenquiries@csiro.au
w www.csiro.au

AT CSIRO, WE DO THE EXTRAORDINARY EVERY DAY

We innovate for tomorrow and help improve today – for our customers, all Australians and the world.

Our innovations contribute billions of dollars to the Australian economy every year. As the largest patent holder in the nation, our vast wealth of intellectual property has led to more than 150 spin-off companies.

With more than 5,000 experts and a burning desire to get things done, we are Australia's catalyst for innovation.

CSIRO. WE IMAGINE. WE COLLABORATE. WE INNOVATE.

FOR FURTHER INFORMATION

CSIRO Land & Water
Dr Bruce Taylor
Senior Research Scientist
t +61 7 3833 5725
e bruce.taylor@csiro.au

CSIRO Land & Water
Dr Elizabeth Hobman
Research Scientist
t +61 7 3833 5625
e elizabeth.v.hobman@csiro.au

James Cook University
Dr Diane Jarvis
t +61 7 4781 6023
e diane.jarvis1@jcu.edu.au