Tropical Water Quality Hub

National Environmental Science Programme

Final Report

Findings from a longitudinal study of farmer decision influencers for Best Management Practices, Queensland, Australia

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Supported by the Australian Government's
National Environmental Science Program
Project 2.1.3 Harnessing the science of social marketing and behaviour change
for improved water quality in the Great Barrier Reef: An Action Research Project

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ACRONYMS

BMP ..... Best Management Practice
CBSM..... Community Base Social Marketing
DAF..... Department of Agriculture and Fisheries
DES..... Department of Environment and Science
DoEE ..... Department of the Environment and Energy
GBR ..... Great Barrier Reef
NESP ..... National Environmental Science Programme
NQ ..... North Queensland
NQDT..... NQ Dry Tropics
NRM..... Natural Resource Management
RRRC..... Reef and Rainforest Research Centre Limited
SMOG ..... “Simple Measure of Gobbledegook” Readability Measurement
SNA..... Social Network Analysis
TPB ..... Theory of Planned Behaviour
TWQ..... Tropical Water Quality
WQ..... Water Quality

ABBREVIATIONS

β ..... Beta
4Ps..... Commercial Marketing’s Product, Price, Place and Promotion
HA..... Hectares
M..... mean
ML..... Mega Litres
SD..... Standard Deviation
p..... Probability
λ..... Lambda

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EXECUTIVE SUMMARY

This is the final report for this project – *Harnessing the science of social marketing and behaviour change for improved water quality in the GBR: An action research project*. It provides an analysis and comparison of data collected from land managers in the Burdekin (two data collection points) and Wet Tropics (WT) (three data collection points) regions. It also provides a number of specific recommendations for key stakeholders regarding possible actions that should be considered in future interactions with land managers. Individual area-specific reports have already been provided to each of the two Natural Resource Management (NRM) organisations in whose regions the data was collected. We note that there were considerable problems with the data collection in both regions, leading to both considerable delays in obtaining the data and lower than ideal response rates and only two rather than the planned three sets of data from the Burdekin region. This has resulted in the analysis of some parts of the data sets being restricted to descriptive statistics. A more detailed discussion of the specific problems faced is provided in the methodology section.

This project aimed to generate information to inform the design of marketing and engagement strategies associated with water quality (WQ) improvement strategies so that they better 'match' the motivations, values and other social characteristics of land managers in the GBR. The findings aim to improve uptake/adoption of WQ improvement programmes with greater associated changes in behaviour and thus greater returns on investment. This project sought to identify the barriers to, and potential enablers of behaviour change in relation to agricultural run-off and to thus encourage BMP uptake amongst land managers who have not previously engaged, either fully or partially in BMP-related activity.

Working in partnership with staff from the Australian Government's Department of the Environment and Energy (DoEE), and the Queensland Government's Department of Environment and Science (DES), this project used data collected from land managers and elsewhere to critically evaluate the way WQ improvement programmes are 'marketed'. Insights from those evaluations were used to inform the reconfiguration of marketing and engagement strategies associated with programmes scheduled for roll-out during 2017.

The key barriers identified were:

- Conflicting information over time from the range of organisations active in this sector, including changing advice from state and federal governments.
- Distrust of government agencies and resentment of what is perceived as unfair blaming of land managers, coupled with denial on the part of some participants in the studies that their activity is detrimental to the GBR.
- Treating all land managers as homogenous rather than tailoring communications to better fit with personality types and level of commitment to best land management practices.
- Resistance of some extension officers to change and refusal to engage in discussions with those land managers who follow different land management practices to those officially advocated.
- Uneven coverage of land manager properties by extension officers, with a concentration on those who are engaged rather than trying to encourage higher levels of engagement from those partially engaged or disengaged.

- Complexity of applications for, and perceived unfairness of, available grant / funding initiatives.

Factors that may encourage uptake of BMP can be summarised as:

- Engagement of extension staff in discussions regarding the implications of the findings presented in this and preceding reports report for their own practice. The discussion of relevance of the findings detailed in this should be led by someone from within their own community who has the necessary skills.
- Upskilling all personnel such as, but not restricted to, extension officers in the application of theory and communication frameworks, especially the principles of social marketing, to practice, the use of a range of social media platforms to communicate to stakeholders, and the importance of visual imagery in reinforcing key messages. We note, however, that some extension officers have shown themselves to be resistant to change, while others feel that any form of innovation is discouraged by their organisations. Where a culture of resisting change or discouraging innovation by organisations exists, then this needs to be addressed by all delivery partners including hosting industry organisations and NRMs.
- Ensuring all communication, by whatever means, sends consistent, integrated messages irrespective of source, and channelling communication through trusted sources.
- Develop systems for monitoring and analysing messages from a range of sources, including the news media and fertiliser reseller and also strategies for minimising the impact of competing and conflicting messages.
- Develop proactive relationships with both traditional and digital media organisations.
- Recognise the overall diversity of information sources and preferences among land managers and tailor information strategies accordingly.
- Incorporate long-term relationship management strategies based on customer relationship management and business to business marketing concepts.
- Develop specific strategies for reaching and engaging those who are less than fully committed to adopting recommended best land management practices.

Note – further details regarding the main recommendations are provided in the Recommendations section of this report.

This report should be read in conjunction with the range of reports previously provided, especially the review of literature in the area and the reports for the related project 3.1.3 which focussed on an analysis of the readability of existing material provided to land managers.

1.0 INTRODUCTION

Adoption of best practice land management (BMP) strategies to improve WQ has been low in some regions and previous water quality programmes may have encouraged BMP only amongst those land managers who were already pre-disposed to management practices. This project sought to encourage BMP uptake amongst land managers who have not previously engaged.

BMP reef-related programmes often assume that land managers are motivated by profit – offering financial (dis)incentives or seeking to 'prove' that BMP will raise profits. Finances are not the sole driver of on-farm conservation activities: socio-cultural and environmental values are crucially important to land managers and residents. Even those who focus on money may not focus on profit; they may instead wish to minimise cost, risk and/or maintain flexibility. This may explain why financial payments for on-farm conservation initiatives do not always generate 'additionality' (the effect or an intervention), and suggests that the incentives used to encourage BMP are unlikely to appeal to all land managers. For a detailed discussion see (Eagle, Hay, & Farr, 2016b)

Importantly, encouraging behaviour change is not simply about getting incentives 'right'. A vast body of literature focuses on behaviour, the 'power of persuasion' and the social acceptance of new knowledge establishing that to change behaviour one must win a 'battle of ideas' for a seminal paper, see Peattie & Peattie (2003). Programmes have an implicit or explicit persuasive message embedded within (Eagle et al., 2016b). Messages can be 'framed' positively or negatively and communicated to target audiences through different mediums (e.g. pamphlets, extension officers). No single mode of framing or communication works in all situations due to a host of interacting factors, including: the intrinsic and extrinsic motivators/incentives, value orientations, descriptive and injunctive social norms, social networks and preferred communication channels of targeted groups; perceptions of intervening barriers/enablers; whether new or existing behaviours are targeted; whether personal freedoms are perceived to be threatened and those involved are 'trusted; and the functional literacy of targets. Different factors may drive the behaviour of different population segments and in different social contexts, hence the need to develop context-specific intervention strategies, see Hay & Eagle (2016a) and Hay, Eagle and Chan (2018) for further discussion.

Consistent with a plea to determine *"what works, for whom, in what circumstances and for how long"* (Marteau, Ogilvie, Roland, Suhrcke, & Kelly, 2011, p. 264), this project uses insights from the science of social marketing and behaviour change to implement (and test the efficacy of) changes to the marketing and engagement strategy associated with programmes designed to be rolled out under the Reef 2050 Plan. It aimed to change key behaviours, particularly amongst those who have not previously engaged, to improve WQ.

1.1 Overall project objectives and anticipated outcomes

The objectives that were set at the commencement of this project were:

Objective 1: Identify intrinsic and extrinsic motivations (motivations), value-orientations (values), norms, 'habits' (particularly relating to NRM), social networks and communication protocols of different segments of land managers (particularly graziers and cane growers) in regions where WQ improvement programmes have recently been, or will soon be, rolled out.

Objective 2: Assess reactions of land managers to complexities of language, message framing and communication channels ('messaging') used in the programmes, perceptions of barriers to and potential enablers of adoption of these programmes, perceptions of 'threats' to personal freedoms and 'trust' in the programme.

Objective 3: Examine similarities and differences in (1) and (2) between the land managers who have (do), and have not (do not), chosen (choose) to participate in the programmes.

Objective 4: Identify mismatches between the extrinsic incentives and marketing messages of evaluated programmes and the motivations, values, norms, habits and communication protocols of both participating and non-participating land managers.

Objective 5: Work with those who are implementing new programmes to use insights from (1) – (4) above, to suggest and, where appropriate, implement 'live' alterations to marketing and engagement strategies, i.e. undertake adaptive alterations to those strategies to encourage participation amongst those likely to be disinclined to participate.

Objective 6: Assess the efficacy of these interventions, determining if they result in changed behaviours that are likely to generate more significant improvements in WQ than would otherwise occur.

The anticipated outcomes include:

- WQ improvement programmes that are designed (and marketed) in ways that better match the motivations and values of land managers in the GBR.
- Greater uptake/adoption of WQ improvement programmes with greater associated changes in behaviour; thus a greater return on investment.
- Insights about land managers and ways to tailor programmes to increase adoption that are transferrable to other contexts.
- Insights into ways of measuring the 'impact' of interventions that are transferrable to other contexts.

1.2 Report Structure

This report provides an update on developments across the project to date including a summary of the literature review key findings in Section 2.0, confounding factors surrounding the project in Section 3.0 and an outline of the methodology for data collection, analysis and structural equation modelling in response to the project schedule in Section 5.3. Section 6.0 provides the results of each round of data collection over three years, 2016 (first round), 2017 (second round) and 2018 (third round). The discussion in Section 7.0 applies the findings as a response to the research objectives and Section 8.8 concludes the project and makes recommendations. This is the final report for this project.

2.0 LITERATURE REVIEW: KEY FINDINGS

2.1 Initial Literature Review

NESP TWQ Hub Project 2.1.3 Initial Report, (Eagle et al., 2016b)

The initial project literature review was intended to provide an extensive review of the existing literature relating to behaviour change, either directly in the agri-environment context, or from wider contexts where findings may then be applied to agri-environmental issues. A specific focus was placed on the use of social marketing approaches, acknowledging the complex range of influences on behaviours and pressures, such as climate change and extreme weather events that are beyond the control of land managers.

The tensions between land managers perceived freedom to manage their land in the way they believe will provide them with the best outcomes, and the range of attempts to influence that behaviour have been well documented in previous studies and were summarised in the initial report. There is a need to recognize the range, complexity and magnitude of barriers to behaviour change together with the need to identify potential enablers of sustained behaviour change.

The major behaviour change tools were reviewed, including the role of behavioural economics and social marketing concepts, together with examples of successful social marketing- based interventions. Two widely used social marketing approaches, Community-Based Social Marketing and the National Social Marketing Centre's Benchmarks were compared and contrasted, with a view to synthesizing them for the agri-environment context. These should be viewed in the context of a range of behavioural influences that are seldom explicitly considered in intervention design. An intention to develop a synthesis of these approaches was signalled in the initial report and recently published in the Journal of Marketing Management (Rundle-Thiele et al., 2018).

As there is a considerable body of evidence regarding the value of using behaviour change theories to help in the analysis of the relative importance of a range of behavioural influences, a discussion of the way theory can be used to underpin future behavioural change interventions is provided. These influences include the impact of conflicting or competing information and the key role of social norms alongside attitudes and beliefs regarding abilities to undertake and maintain behaviours.

The influence of limited literacy and numeracy abilities for a large percentage of the population is under-recognised in behaviour change activity. Therefore, these factors are reviewed, together with other cognitive limitations such as the ability to perceive environmental impacts over a long period of time. Tools for evaluating the readability of printed material (including Internet-based material) were noted in this report but covered in depth in a separate report (Hay & Eagle, 2016a. Harnessing the science of social marketing and behaviour change for improved water quality in the GBR: Documentary Analysis). This is followed by a review of the impact of message framing and message tone factors and the use of visual imagery and subsequent 'Best Practice Guide' (Hay et al., 2018. NESP TWQ Hub Project 3.1.3 Harnessing the science of social marketing and behaviour change for improved water quality in the Great

Barrier Reef: Final report best practice guide for development and modification of program communication material.).

As agri-environmental behaviour is strongly influenced by a complex range of social factors such as peer approval, the importance of communities and social networks in accepting the need to change and adapt behaviours, a discussion of the importance of the need to understand the interplay of these factors was included. This was followed by a review of collaborative approaches to behaviour change, including knowledge brokerage, social learning and collaborative partnerships and co-management activity.

This review formed the foundation for the development of the research questions used in the first round of data collection (see Farr, Eagle, & Hay, 2016).

2.2 Additional Literature since the Original Review

Recent additions to the academic literature include multiple papers relating to the health of the Great Barrier Reef, but excluding specific marine science analyses of specific parts of the ecosystem. Examples of recent literature relevant to this project include:

- Crown-of-thorns starfish outbreaks, with increasing recent citations of a paper (Miller et al., 2015) suggesting that direct linkages of outbreaks to increased levels of nutrients such as fertilizer in water may have been overstated.
- Coral bleaching causes and effects (see, for example, Wolanski, Andutta, Deleersnijder, Li, & Thomas, 2017). Coverage of the back-to-back bleaching events and recent cyclones have also led to acknowledgement that the GBR is "under pressure from a suite of stressors" (Wolff, Mumby, Devlin, & Anthony, 2018, p. 1978)
- Impact of mining, with one paper suggesting the recently approved Adani mine will be a "public health disaster" (McCall, 2017, p. 588). We also note significantly increased media coverage of this issue (see Section 3.2)
- Concerns about the lack of an integrated catchment-wide management structure (see, for example, Dale et al., 2017) and criticisms of both the complexity of legislative and regulatory systems together with 'political ideology' that are seen as a barrier to more effective adaptive management practices (Tan & Humphries, 2018). There is also a global call for ecosystem management structures "that better balance conservation objectives and stakeholder interests" (Weijerman et al., 2018, p. 1823).
- Concerns regarding the limited success of water quality improvement programmes (De Valck & Rolfe, 2018) and the need for cooperation between management agencies (Day, 2018).

Two factors stressed in the original literature review have received recent focus: The first highlights the need to consider both the economic and social influences on sugar cane farmers' run-off management (Deane et al., 2018, p. 691). The need for transparency, accountability, equity and fairness are highlighted as necessary for effective practice change. The second related to the need for trust in natural resource management communication (MacKeracher, Diedrich, Gurney, & Marshall, 2018, p. 29). Deane et al., (2018) also stresses that the provision of information alone is insufficient to change behaviours.

While there are very few human-factor focussed agri-environment papers, there is a growing focus on extension workers and their challenges, particularly in developing countries, especially in Africa (Bachewe, Berhane, Minten, & Taffesse, 2018; Cafer & Rikoon, 2018; Shitu, Shitu, Nain, & Singh). The small amount of material relevant to the Australian context offers some interesting potential for development, including extension support services via digital platforms (Mushtaq et al., 2017) and privatised extension services (Paschen, Reichelt, King, Ayre, & Nettle, 2017).

3.0 CONFOUNDING FACTORS

3.1 Water Quality Improvement Programmes

Water quality improvement programmes in the Great Barrier Reef regions are primarily funded by the Australian and Queensland Government with the primary objective to reduce sediment, fertiliser and pesticide run-off into the GBR Basin. Confounding factors include multi-organisation involvement in research in the GBR catchment area.

During the NESP TWQ Hub research (2015-2021) there have been a number of 'competing', and, at times, 'conflicting', activity that is underway in both the Wet Tropics and Burdekin regions. For example:

- "Cane Changer" (Canegrowers) John Pickering – includes similar questions to those already used in the first round of 2.1.3).
- "Landscape Resilience" (NQ Dry Tropics, Lisa Pulman).
- "Project Catalyst" (Reef Catchments, Terrain, NQ Dry Tropics, Australian Government – involves commercial partners such as Coca-Cola, WWF and Bayer).
- Announcements re additional funding via Reef Trust Phase IV Repeated Tenders – See press release Terrain 19 June re $4.7 million in funding. Similar statements ex NQ Dry Tropics.
- Grazing Best Management Extension Support
- SmartcaneBMP
- "Project NEMO"
- Sandy Creek (Pioneer River Floodplain – Mirani: inland from Mackay)
- "Connecting cane farmers to local wetlands" (NQ Dry Tropics, Laura Dunstan)
- Major Integrated Projects.

Therefore, the measurement of effects of any specific intervention are limited in that no one programme's success can be singularly measured within the regions.

3.2 Mass Media and Digital Media

We also note a significantly increased level of media activity regarding the health of the Great Barrier Reef in 2017 compared to 2016, particularly as a result of two consecutive years of coral bleaching and a number of conflicting reports regarding the extent and consequences of this (for a review of the key themes within mass media in 2016, see Eagle, Hay, & Low, 2018). This analysis was not part of the original project objectives but was undertaken to fill a gap in knowledge regarding the impact of media activity. It is noted in the Recommendations section that it would be beneficial to extend this analysis to incorporate 2018 and 2019 data and that some form of ongoing tracking and analysis of media coverage should be implemented.

Table 1: Media activity regarding the health of the Great Barrier Reef theme of article by time period

Theme	2016		2017 Jan - June		2017 July- Dec	
	n	%	n	%	n	%
Coral bleaching	59	24.4	161	21.7	41	3.0
Climate change / global warming / ocean acidification	34	14.0	156	21.1	126	9.2
Reef is dead / dying	25	10.3	41	5.5	11	0.8
Coal mining including Adani / dredging	25	10.3	87	11.7	194	14.1
Funding increase calls	20	8.3	7	0.9	0	0.0
UNESCO potential 'at risk' listing	19	7.9	4	0.5	19	1.4
Plastic bag ban	13	5.4	0	0.0	14	1.0
Shipping	12	5.0	15	2.0	22	1.6
Scientific disputes and controversy	11	4.5	5	0.7	11	0.8
Government actions including funding commitments	6	2.5	9	1.2	90	6.5
Water quality improvement	5	2.1	13	1.8	36	2.6
Reef Report card / Reef health reports	5	2.1	4	0.5	97	7.1
Cane monitoring compliance	4	1.7	0	0.0	0	0.0
Agriculture including Farmer protest negative portrayal	4	1.7	6	0.8	26	1.9
Solutions, Hope and Recovery	0	0.0	41	5.5	98	7.1
Sea Turtles	0	0.0	16	2.2	8	0.6
Travel Articles – encouraging visits to GBR	0	0.0	50	6.7	123	8.9
Advocacy, activism, Not-for-profit activity & Individual Actions	0	0.0	14	1.9	65	4.7
Cyclone Debbie & Whitsundays impact	0	0.0	34	4.6	12	0.9
Financial Costs and Impact on Tourism of bleaching etc. articles	0	0.0	12	1.6	43	3.1
Research: planned studies, laboratory experiments (e.g. coral cloning)	0	0.0	39	5.3	83	6.0
Deloitte Valuation of GBR	0	0.0	22	3.0	7	0.5
Chasing Coral	0	0.0	0	0.0	42	3.1
Crown of Thorns / Triton	0	0.0	0	0.0	25	1.8
Other: GBR mentioned only in context of wider unrelated content	0	0.0	5	0.7	182	13.2
Total	**242**	**100**	**741**	**100**	**1375**	**100**

The key themes emerging from the non-academic media in 2016 include:

- Global warming / ocean acidification / coral bleaching, including missed and conflicting reports regarding bleaching versus recovery.
- Plastic pollution including, recently, concerns that corals are ingesting plastic debris (Allen, 2017).
- Impact of mining, particularly the Adani mine and associated protests.
- Land clearing.
- Criticism of the draft 2050 water quality improvement plan.

Eagle et al. (2018) warned that the overwhelmingly negative tone of this coverage is likely to erode public confidence in reef-related science. In addition, the authors warned of the possible consequences of disagreement within the scientific community and its impact on the overall credibility of science, particularly when no overt attempt is made to correct misconceptions. Criticism of possible exaggeration of coral bleaching reports became evident in 2016 (see, for example, Lloyd, 2016) and 2017, including impacts on tourist's perceptions (Millard, 2017) as well as on climate sceptic-supported sites (see, for example, Steele, 2017).

A detailed analysis of the 2017 media is currently in press and will be made available on completion. However, the authors draw attention to the potential impact on stakeholders, such as land managers, of persistent sensationalised and predominantly negative media coverage of the GBR as this is likely to reinforce and strengthen perceptions that agriculture is being unfairly blamed for water quality issues.

This is also reinforced by multiple documents and papers that acknowledge water quality improvement targets are unlikely to be met, for example:

- "Queensland is likely to fail to achieve the reef water quality targets essential for maintaining the health and resilience of the Great Barrier Reef" (Queensland Government, 2017, p. 5)
- "On current trends transformational change in adoption rates will be needed to meet various targets for water quality improvements" (Rolfe & Harvey, 2017, p. 277)
- "There is limited empirical evidence in the GBR of the water quality improvements likely to result from changes in agricultural practices" (Thorburn & Wilkinson, 2013, p. 193)
- Even three decades ago there were concerns "We conclude that recent efforts in the GBR catchments to reduce land-based pollution are unlikely to be sufficient to protect the GBR ecosystems from declining water quality within the aspired time frames" (Kroon, Thorburn, Schaffelke, & Whitten, 2016, p. 1985)

These authors continue their somewhat pessimistic analysis, stating that modelling suggests that "even complete adoption of industry-supported BMPs for reducing sediment and nitrogen discharges from the GBR catchments would not achieve water quality targets stipulated in government policy".

Given that the first round of data collection showed a high percentage of land managers did not believe their practices had any effect on the health of the Great Barrier Reef, this coverage is likely to reinforce and possibly even increase these perceptions.

3.3 Directions for Further Research

In order to fully understand the extent and nature of discussions regarding the health and future of the GBR it is recommended that social media discussions, online video coverage and documentaries of the GBR be contrasted with material from traditional media sources to establish the effect of media on land managers beliefs about the effects of farming on the health of the GBR, see Eagle, Hay and Low (2018).

There was a change of tone reflected in news media coverage between 2016 (242 articles) and 2017 (741 articles). For example, in the first six months of 2017, the tone of articles in the news media moved from mostly neutral (37.2%) to mostly negative or very negative (52%). Similarly, while articles of hope and recovery increased slightly from 0% to 5.5%, they still do not portray positive outcomes for the GBR. There are also new factors entering the news media coverage themes e.g. algae and lower sea temperatures (Copp, 2017) and comments regarding the imminent demise of the GBR are increasing, but also that the long term impacts have yet to be evaluated. Given that the first round of data collection showed a high

percentage of land managers did not believe their practices had any effect on the health of the Great Barrier Reef, this coverage is likely to reinforce and possibly even increase these perceptions. Therefore, it is recommended that news media be contrasted and reported to identify trends in the media, which may influence land managers opinions and behaviour.

Further research is required on the actual impact of tourism on different sections of the GBR and an analysis of the impact of the tourism industry's strategies to mitigate the impact of sensationalized reporting of likely future tourism experiences.

These analyses may then be used to inform a critical analysis of existing science communication models to guide the development and testing of potential new models that may be more applicable in the digital era.

4.0 CRITICAL EVALUATION OF MARKETING STRATEGIES USED FOR REEF PROGRAMME AND THE REEF TRUST TENDER

NESP TWQ Hub Project 3.1.3 Document Readability Analysis (Refer to Hay & Eagle, 2016 for full report)

The document readability analysis project critically evaluated programme marketing material with the intention to assess the way that messages to land managers about water quality in the Great Barrier Reef are presented in terms of their readability, message framing, and message tone. Two programmes were selected (1) the Reef Programme (Wet Tropics and Burdekin) and (2) the Reef Trust Tender (Burdekin). The programmes selected for evaluation had been marketed within both the wet and the dry tropics, and they had been designed for both graziers and cane farmers.

Overall, the readability analysis has shown all three programmes to be written at a similar level well above the recommended reading level of grade / year 9 (Carbone & Zoellner, 2012; Kemp & Eagle, 2008). The documents associated with the Reef Programme (Burdekin), with a "Simple Measure of Gobbledegook" (SMOG) Readability Measurement score of 13, were slightly more readable than documents associated with the Reef Trust Tender (Wet Tropics) (SMOG score of 17) or the Reef Programme (Burdekin) (SMOG score of 18).

A readability score of 18 or above requires the reader to have achieved a university degree and a score of 17 means that they must have received a level of further education beyond high school, whereas for the readability level of 13 the reader must have at a minimum completed and passed high school. Therefore, the analysis of water quality programme marketing material indicates that many of the communications are written in language too complex for a substantial percentage of the Australian population.

Each of the programmes analysed rated slightly different in terms of norms, tone and message framing used. Most of the documents were written using positive and negative framing and used both fear and guilt appeals. Some messages appeared to be collaborative and both injunctive and descriptive norms were used to demonstrate approved methods of what land managers ought to be doing and how other land managers were behaving. However, the materials were largely dictatorial and sometimes patronising.

During the analysis, it became evident that there were limitations to the materials content imposed by various Government Guidelines and the unavoidable use of three syllable words such as government and management, which affected readability heavily.

Due to the nature of message communication, there are no standard rules to apply to norms, message tone and framing. However, understanding the principles of communication can help to deliver messages appropriate to the given audience see Hay et al., (2018).

The outcomes of the document readability analysis were used to inform stakeholders within and beyond the regional natural resource management groups who supply the current programmes to land managers. As a result, project managers from the wet and dry tropics

have implemented changes to their marketing communication material with positive results (see Section 7.4).

Visual imagery was not a major focus on this project, but, given the importance of visuals in effective communication noted in the academic literature, we recommend that additional resources be targeted at examining this in a similar way to the readability analysis.

NESP TWQ Hub Project 3.1.3 Harnessing the science of social marketing in communication materials development and behaviour change for improved water quality in the GBR: Readability Desktop Review, drew on learnings from NESP TWQ Hub Project 2.1.3 and from other past research to conduct a readability, message tone and visual imagery analysis of communications material from a selection of programme documents supplied by Australian and Queensland Governments and other program managers as well as extension service providers with the aim of increasing uptake of water quality improvement programmes in the Great Barrier Reef Basin (see Section 7.4 Research Objective 5 for examples of how the results from NESP TWQ Hub Project 3.1.3 have been incorporated into water quality programs).

5.0 METHODOLOGY

5.1 Survey

Surveys of land managers were undertaken in partnership with two of the six natural resource management (NRM) organisations operating in areas adjacent to the GBR identified as having a very high risk of natural and anthropogenic run-off (Brodie, Waterhouse, & Maynard, 2013). NRM organisations, of which there are 56 in Australia, act under delegated authority from the Federal Government to coordinate environmental management within their regions. The sample population was obtained from a membership database within the Wet Tropics and Burdekin regions. Participants include land managers from the both regions who engaged in sugar cane production and cattle production. Quantitative and qualitative data were analysed including open-ended responses.

The survey was developed using information gathered from an initial literature review related to the science of social marketing (see Eagle et al., 2016b for more details) and from literature surrounding agriculturally relevant behaviours that impact water quality (Churchill, 2017). The need to alter approaches to behaviour change has been accepted by government agencies including the need to determine *"what works, for whom, in what circumstances and for how long"* (Marteau et al., 2011, p. 264).

Studies have shown "*that behaviour change is more likely when more components of social marketing are used*" (Almestahiri, Rundle-Thiele, Parkinson, & Arli, 2017, p. 234). As with other complex areas, Best Management Practice-focussed behaviour change activity lends itself to a Social Marketing approach via an understanding of the influence of intrapersonal, interpersonal, organisational, community and societal influences on behavioural decisions across different segments of land managers. Social marketing is an approach that calls on a variety of theoretical models. It is multidisciplinary and it provides a framework for developing innovative solutions using a substantial research base to initiate change across communities, organisations and society (Lefebvre, 2013). This approach is compatible with advocated conservation marketing strategies (Bennett et al., 2017; Veríssimo, 2013; Wright et al., 2015).

5.2 Measurement Instrument

The questionnaire development included several rounds of feedback from stakeholders including government and industry specialists, which resulted in an operational definition of the Theory of Planned Behaviour (TPB) constructs. Use of a structured measurement instrument in this study was justified from previous studies - it is a widely used approach of data collection when the purpose is for testing the relationship of established theories (such as TPB in this current study) (Field, 2017). Using the structured measurement instrument and survey methods provides control over the data collection process, it is relatively easy to administer, cost effective, and ultimately provides flexibility in subsequent data analysis (Bickman & Rog, 2009).

5.2.1 Survey Methodology Limitations

Data collection for the second round was continuously delayed in both NRM regions. Both NRMs raised concerns about the data being shared with government departments and the possibility of it [the data] being "used against us" [the NRMs]. In addition, NQDT were investigating third party collection using industry partners to fulfil their contract as both the quantity and quality of the Wet Tropics data (collected by the extension officers face-to-face), was far better than the NQDT data that was collected via phone using graduate students.

Requests to make changes to the questionnaire by NQDT to suit the newly created MIP activity were acknowledged and a small number of modifications to the questions were made as requested. However, changes were not made to the detriment of the original objective of the survey as this would have prevented any comparison being made between data collected at different time periods and therefore prevent any measurement of behaviour change.

While Terrain NRM initially indicated that they would collect data via an online questionnaire delivery, the method was changed whereby NRM extension officers completed their questionnaire online, and administered the survey (including some common questions) face to face with cane growers. This raises the issue of potential data contamination if extension staff seek to align responses with their own responses see Section 6.2.3 Limitations. Second round data collection commenced in the Wet Tropics region in late October 2017 (delayed from the intended July 17 start date) with a shortened version of the questionnaires in order to focus on a small number of behavioural areas. Concerns regarding a late change to the data collection strategy within the Wet Tropics region were ratified, resulting in significant delays in reporting for each round of data collection.

5.3 Structural Equation Modelling

5.3.1 Structural Equation Modelling

Structural equation modelling (SEM) is a statistical procedure that uses data and qualitative causality expectations for analysing and estimating causal relationships (Jahanshahi & Hall, 2013) between the variables (see Appendix 0 for an overview of SEM). SEM is a system of equations and is a very powerful multivariate technique, which has been recognised as one of the most suitable analytical tools to investigate and understand complex interrelated relationships within the Theory of Planned Behaviour (Eagle, Hay, & Farr, 2016a; Gunzler, Chen, Wu, & Zhang, 2013). The approach has been widely used in TPB-based studies mostly in health (Adams & Boscarino, 2011; Bryan, Schmiege, & Broaddus, 2007; Vadaparampil, Champion, Miller, Menon, & Skinner, 2004), travel (Bagley & Mokhtarian, 2002; Golob, 2003), diving (Ong & Musa, 2012), and shopping (Hellier, Geursen, Carr, & Rickard, 2003; Homer & Kahle, 1988). SEM allows the structural relationship between variables in the model to be *"modelled pictorially to enable a clearer conceptualization of the theory under study"* (Brain, 2008, p. 3). *"Relative weights of model constructs are determined empirically for the particular behaviour and population under investigation. This information provides guidance as to which constructs are most important to target for behaviour change effort"* (Glanz, Rimer, & Viswanath, 2008, p. 76). As such, the SEM has been chosen as the most appropriate approach to analyse land managers' behaviour in this project.

5.3.2 Fertilizer application behaviour

Farmers were engaged in six different types of fertilizer application behaviours (see Appendix 1 for a summary of measurement items). Feedback from stakeholders indicated that the industry standard 'six easy steps' was the desired fertilizer application behaviour (Reef Water Quality, 2016), therefore a binary approach was followed to operationalize fertilizer application behaviour. The industry standard 'SIX EASY STEPS' was coded as '1' (desired probable behaviour) while all other practices were coded '0'.

5.3.3 Run-off practices

Handling run-off practices was also conceptualised in the context of TPB, where farmers adopted four different types of run-off practices. Insights from stakeholders indicated that using 'recycle pits (Burdekin) or sediment traps (Wet Tropics)' was the desired practice for handling run-off. 'Recycle pits/sediment traps' practices were coded as '1' (desired probable behaviour) while all other practices were coded as '0'. We highlight that recycling pits are used in the Burdekin, whereas sediment traps are only useful in the Wet Tropics if there is sufficient sediment generated of a suitable grain size (>64um) and there is room and appropriate landscape position to install one. The data is representative of those growers who indicate that they were currently using sediment traps.

Farmers were advised to reflect on their attitude towards fertiliser application behaviour and handling run-off practices where subjective norms, perceived behavioural control and motivations towards behaviour were all conceptualised and measured in the same way, as follows.

5.3.4 Attitudes, perceived norms and perceived behavioural control

Attitudes towards fertilizer application behaviour were measured using a 4-items scale[1]. A single item measured subjective norms while the perceived behavioural control construct was measured by using a 3-items scale.

5.3.5 Motivations towards behaviour

Four different sets of motivations guiding fertilizer application behaviour: lifestyle, financial or economic goals, social goals and environmental goals were conceptualised *(Farr, Eagle, Hay, & Churchill, 2017b)*. Lifestyle, financial or economic goals, and social goals each were measured by using 5-items scale, while a 6-items scale measured environmental goals.

Responses on all items were recorded on a 7-point Likert scale (1 'extremely unimportant' to 7 'extremely important').

[1] Items scale – relates to a number of statements that are measured on a Likert scale, in this instance a 7-point Likert scale (1 'extremely unimportant' to 7 'extremely important').

5.3.6 Limitations of SEM relevant to the research

Although considerable care was exercised in design and execution of the project, there are some theoretical as well as methodological gaps that need to be addressed in further investigate water quality change behaviours. These gaps are related to how the TPB model is developed and executed in this study.

As a tool to identify factors that play a major role in behaviour change using a social marketing approach, the TPB requires a specific schematic conceptualization and organization of its constructs considering the causal chain process proposed in its original form. Additionally, the extended form of TPB requires to consider a more in depth analysis of how beliefs are formed and affected by background factors. This belief-based approach of measurement is more effective than direct measurement. Based on these additional considerations, the following suggestions are provided:

- As the TPB was found to be the most appropriate to exploring factors explaining farmers' fertilizer application and run-off handling behaviours, the measurement of such behaviours needs to be revisited. Fishbein and Ajzen (2010a) suggest that the actual behaviour under study in the TPB proposal should be measured at a certain level of specificity including reasonable time and a clear description of action.
- Further to revised measurement of actual behaviour, another important aspect of the TPB proposal is that it follows a particular schematic arrangement of various constructs to predict actual behaviour. Behavioural intention is considered as one of the most important constructs in the TPB proposal that is considered as an immediate proxy of actual behaviour. The reason why behavioural intention is often considered more important than the actual behaviour is because the actual behaviour is contingent to the availability of chances and choices, whereas, the behavioural intentions are free from such controls. Even if the product availability or probability of behavioural occurrence is not possible at a particular time, behavioural intentions are still the true outcome of factors found to be affecting them. This is because behavioural intentions represent present or future plans of action or choice which is not affected by certain behavioural controls at any specific time. Nevertheless, this does not limit the prediction of actual behaviour as the TPB proposal explicitly clarifies that the behavioural intentions are tantamount to actual behaviour. Therefore, it is critical to examine behavioural intentions prior to actual behaviour while the TPB proposal is implemented.
- As this project was limited to direct measurement and explanation of actual behaviour, no relevant behavioural controls were defined or measured. In the actual TPB model, behavioural intentions are translated into actual behaviours, subject to favourable controls. Fertilizer application and Run-off handling behaviours are also a very complex set of behaviours and need to be examined closely to identify if there are any factors that might hinder (or facilitate) farmers intentions to actually convert into actual behaviour.
- Another limitation of the TPB model utilized for fertilizer application and Run-off handling behaviour in this project is the level and specificity of attitudinal measures that lead to behavioural intention and consequently actual behaviour. While Fishbein and Ajzen (2010b) advised that attitudinal constructs (subjective norms, attitude towards behaviour and perceived behavioural control) should be measured at the same level of specificity as the actual behaviour under study, this project could only utilize similar

measures of subjective norms, attitude towards behaviour and perceived behavioural control. This needs to be revised as there are chances that the elements of subjective norms, attitude towards behaviour and perceived behavioural control may differ for the two different types of behaviours.

Finally, Fishbein and Ajzen (2010b) maintain that belief-based measures of subjective norms, attitude towards behaviour, and perceived behavioural control are stronger than direct measures of these constructs. They provide a value-expectancy-model to justify why belief based measures are stronger than the direct measures. It is therefore suggested to reconfigure the belief based measures of these constructs based on methods suggested by Fishbein and Ajzen (2011).

6.0 RESULTS

A comparative evaluation of the effectiveness of water quality programs and their ability to alter water quality related behaviours.

6.1 First Round (2016/17) Data Summary of Findings

Detailed reports were provided individually produced for the Burdekin (Farr, Eagle, Hay, & Churchill, 2017d) and the Wet Tropics regions (Farr et al., 2017b) regions, followed by a report comparing and contrasting the findings from the two regions (Farr et al., 2016). These reports detailed the survey instrument development and sampling design. The reports provide a preliminary descriptive statistical analysis of the initial data collected from land managers. They also provide provisional recommendations for key stakeholders regarding possible actions that should be considered in future interactions with land managers, these recommendations are also presented in Section 8.4 of this report). An additional technical report was provided giving detailed rationale for the research methodology and the selection of the TPB as a framework for questions and the intended structural equation modelling analysis (Farr, Eagle, & Hay, 2017a)

6.1.1 Burdekin and Wet Tropics Sugar Cane, Results from Round 1 Land Managers Survey

Two questionnaires were developed for the initial round of data collection – one for cane growers and one for graziers. When developing questionnaires, the aim was to keep questions similar in each questionnaire wherever possible, to enable comparisons between both groups (e.g. socio-demographics, attitudes and motivations) and between the case study areas (e.g. cane growers in the Wet Tropics and cane growers in the Burdekin). Identical questions were used to capture demographic information. The remaining questions were similar but made specifically relevant to particular behaviours for the grazing and sugar cane industries. The final versions of the questionnaire are included as Appendices in the reports noted above.

The preliminary analysis primarily captured land managers who were already engaged in programs, including those that related to water quality improvement. Land managers who were disengaged or only partially engaged with agri-environmental issues, were not included in this sample.

Insights from the preliminary analysis of round one data showed that the respondents (n=134):

- Have a mature profile - the median age of cane growers in the Wet Tropics is 57 and cane growers and graziers in the Burdekin is 52 years which is significantly greater than the median age of the Australian population (37 years).
- Own or own and manage their property (65 per cent of cane growers in the Wet Tropics and 80 per cent of cane growers and 84 per cent of graziers in the Burdekin).
- Have lengthy land management experience - (average of 29.2 years in the Wet Tropics, 18.9 years for graziers and 20.9 years for cane growers in the Burdekin), often following earlier generations on properties: maintaining traditions and heritage is important (63%

of cane growers in the Wet Tropics and over 50% of respondents in the Burdekin indicated this to be of the highest importance).

- Do not make decisions in isolation (43% of cane growers in the Wet Tropics and 41% of cane growers and 66% of graziers in the Burdekin) – family / extended family are commonly involved.
- Are positive about overall quality of life (>90% in both regions).
- Have no significant plans to change future practices (>90% in both regions).
- Do not believe their farming practice adversely impacts water quality in local streams, rivers, and waterways (42% of cane growers in the Wet Tropics and 61% of cane growers and 30% of graziers in the Burdekin).
- Do not believe that the cane/grazing industry plays a significant role in the declining health of the Great Barrier Reef (GBR) (49% of cane growers in the Wet Tropics and 66% of cane growers and 39% of graziers in the Burdekin).
- Tend to shift the blame related to poor water quality and the poor health of the Great Barrier Reef to other industries, organisations and individuals.

The first round of data collection made specific recommendations regarding the role of extension officers:

"There is a potential to extend the key role of extension officers in potentially influencing increased uptake of BMP practices. There is a need to recognise the key role of extension officers and determine what professional development support might be beneficial in continuing to build trust and engagement with land managers" (Farr et al., 2016, p. 63).

However, extension staff had discussed with the members of the research team that they were not encouraged to have contact with disengaged land managers but rather to concentrate on those already engaged. This is consistent with findings from other countries, for example the USA where reluctance to try to build new relationships was evident, with the rationale that expending resources on the disengaged could negatively impact on existing relationships with those who are engaged and thus receptive to practice change (Diem, Hino, Martin, & Meisenbach, 2011). This may also be due to short funding cycles and specific targets that programs require resulting in the tendency for extension providers to focus on growers already willing and engaged to ensure outcomes are met. One extension officer from this study noted that they had been told not to visit farms run by members with a specific surname because they were disengaged. However, when the research team investigated further, it appeared that there are several unrelated families in the same region with the same surname, only one of which is disengaged. This means that three other farms had not been visited by extension officers. In addition, extension officers in the two surveyed regions have told the research team that they are not encouraged to be innovative, new ideas are not encouraged by either management or longer-serving fellow extension officers.

The round one data also highlighted that there is a high percent of land managers who do not believe that their actions impact on the GBR, identifying a clear need to "sell the science":

> "There is a need to 'sell the science' to gain acceptance of the cause-effect relationship between farming practice and water quality. NRM groups should

work with environmental science specialists to change views on the impact of farming practice on water quality" (Farr et al., 2016, p. 56).

However in the initial literature review (Eagle et al., 2016b), we noted that there are problems with the levels of trust in government-originated information, and thus also with *"governments' appraisal of causes and extent of 'environmental problems" (Emtage & Herbohn, 2012, p. 358).*

6.1.2 Round 1 Structural Equation Model Results

Note: The results of the Round 1 structural equation model is published with the Asia Pacific Journal of Marketing and Logistics Information (March 2019). The journal article is entitled *"Social Marketing's Role in Improving Water Quality on the Great Barrier Reef" (2019)*, see Section 8.4.

The Theory of Planned Behaviour (TPB) informed questionnaire enabled structural equation modelling to be undertaken with Round 1 data from the cane grower surveys (the Wet Tropics and Burdekin regions) to measure the strength and nature of a range of possible behavioural influences to explain current behaviours and, more importantly, to determine which of the influences should be targeted in future interventions to enhance the likelihood of behaviour change and where there are significant barriers that should be targeted to minimise their effect. Grazier data will be included in structural equation modelling in the third round of data collection.

Two types of behaviours were examined for cane growers: fertilizer application behaviour and handling run-off practices. Fertilizer application and handling run-off practices behaviour in GBR region strongly affects the water quality and consequently leads to changes in biodiversity. The TPB was adapted to explain the factors influencing farmers' cane growing practices. TPB has been widely used in the literature and is reported to have strong explanatory power for several behaviours in social, societal, environmental and enviropreneurial marketing research (Ajzen, 1991, 2015; Bamberg & Schmidt, 2003; Carrington, Neville, & Whitwell, 2010; Fishbein & Ajzen, 2010a). See Section 5.0 for an outline of the methodology and Appendix 1 for a summary of the measurement items.

The findings indicate that the farmer's choice of fertilizer application according to industry standard was positively influenced by elements of life style and social goals through attitude towards behaviour (see Table 2). Similarly, there was positive influence of environmental goals on fertilizer application behaviour (following the industry standard) through subjective norms (farmers I respect most do this). An interesting aspect in these findings is that some of the factors influencing farmers to follow industry standards in fertilizer application failed to cast any impact directly, for example 'being able to make my own decisions' ($\beta 1 = 0.052$, $p < 0.05$), 'sharing new ideas with others' ($\beta 1 = 0.040$, $p < 0.05$) and 'having efforts recognised by the larger community' ($\beta 1 = 0.019$, $p < 0.05$) had no effect on choice of fertiliser application. However, when mediated by a positive attitude towards behaviour, their influence became significant. This supports the conceptualisation that pro-social/ environmental behaviours can be better understood in a theoretical framework rather than in isolation.

Table 2: SEM Indirect Effects of Fertilizer application behaviour through 'Least time consuming'

Predictors (X)	Consequent										
	Fertilizer Application behaviour (Y)		Attitude towards behaviour 'Least time Consuming' (M)		Indirect effect		Confidence intervals		Model Fit		Status
	Coefficient	SE	P	Coefficient	SE	P	Coefficient	LL95%CI	UL95%CI	Negalkarke R^2	Level of mediation
Lifestyle											
Maintaining physical and mental health of family	0.153	0.077	0.048	0.302	0.113	0.007	0.046	0.002	0.128	0.0283	Partial mediation
Maintaining family traditions and heritage	0.151	0.077	0.05	0.209	0.073	0.004	0.031	0.0007	0.0904	0.0421	Partial mediation
Maintaining good relations with other farmers	0.131	0.137	0.923	0.289	0.110	0.009	0.047	0.0016	0.1353	0.0242	Full mediation
Social Goals											
Being able to make own decisions	0.035	0.167	0.831	0.325	0.135	0.017	0.052	0.003	0.138	0.024	Full mediation
Sharing new ideas with others	0.129	0.117	0.268	0.271	0.092	0.003	0.040	0.002	0.113	0.031	Full mediation
Having efforts recognized by the larger community	0.026	0.075	0.723	0.154	0.077	0.047	0.019	0.0002	0.0634	0.023	Full mediation

Figure 5.1 provides an estimated model for fertilizer application behaviour in the Wet Tropics and Burdekin regions. The dotted lines represent indirect relationships, * partial mediation, ** full mediation, Lifestyle 1: maintaining physical and mental health, Lifestyle 2: maintaining family traditions and heritage, Lifestyle 3: maintaining good relations with others, Social Goals 1: being able to make own decisions, Social Goals 2: sharing new ideas with others, Social Goals 3: having efforts recognized by larger community, Environmental Goals 1: maintaining and improving water supplies and storage, Perceived Norms; farmers I respect do so.

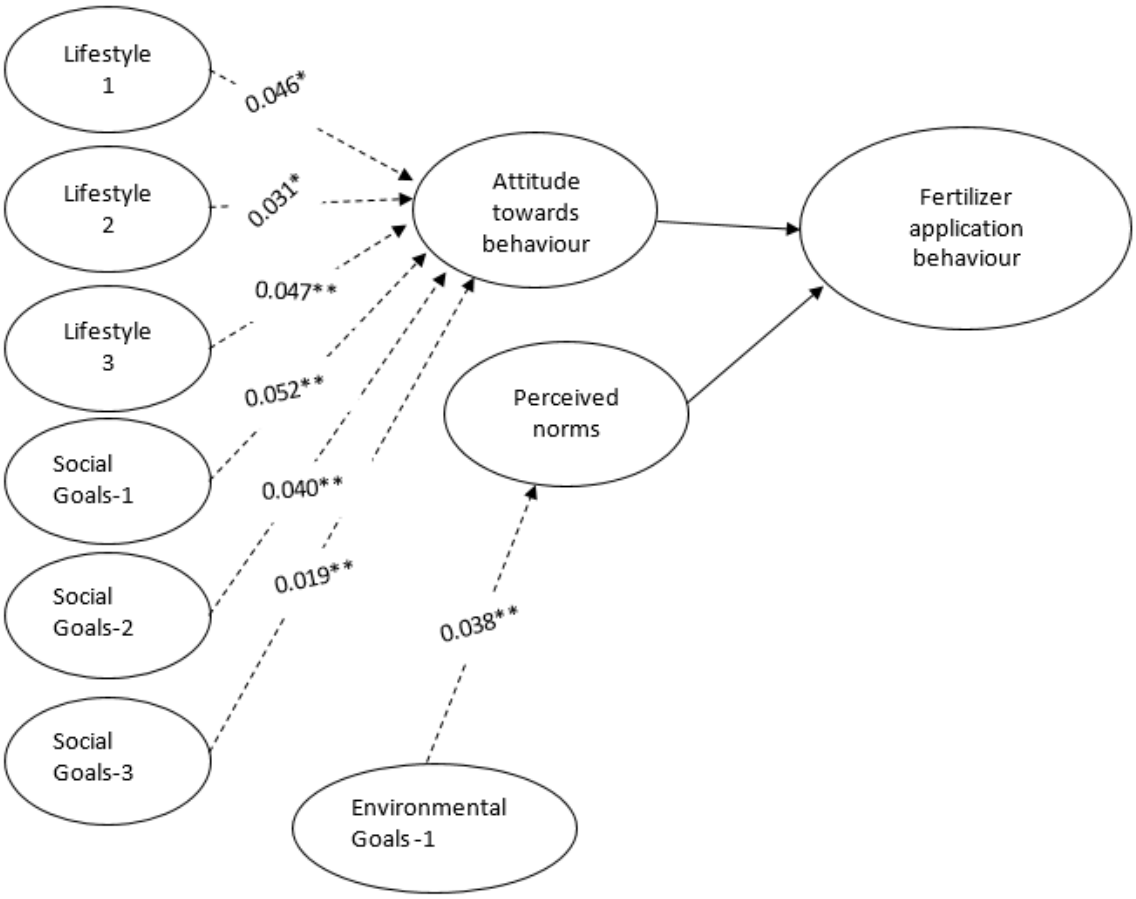

Figure 1: Estimated Model of Fertilizer Application Behaviour, Wet Tropics and Burdekin

For practices related to handling run-off , the sample from the Wet Tropics was used because, (a) the sample from the Burdekin was too small to estimate the model and (b) the combined sample was not methodologically feasible to use. Differences in handling Run-off practices exist among the farmers of Wet Tropics and the Burdekin (thus causing heterogeneity in the sample characteristics).

The results found that for farmers in the Wet Tropics the practice of using recycle pits or sediment traps for handling run-off was influenced by several motivational factors through attitude towards behaviour ('Least time consuming' and 'Best way to reduce business risk') (see Table 3 and Table 4)

Results show that attitude (i.e. least time consuming) negatively mediated the relationships of lifestyle activities with handling run-off practices, including maintaining family traditions ($\beta 1 = -0.142$, $p < 0.05$), spending face-to-face time with family ($\beta 1 = -0.119$, $p < 0.05$), keeping in

contact with family and friends (β1 = -0.109, $p < 0.05$) and maintaining good relations with other farmers (β1 = -0.143, $p < 0.05$). Interestingly, two relationships 'Spending face to face time with family' and 'maintaining good relations with other farmers/graziers', reflected full mediation[2] (see Table 3 and Table 4).The data is representative of those growers who indicate that they were currently using sediment traps. Growers have identified lifestyle activities and relationships as important to decision making, for example if a grower was to decide between taking the family on an annual holiday (tradition) and implementing sediment traps then they would choose a holiday because relationships are more important than sediment traps, so decisions about using sediment traps may not only be about cost.

Financial motivations including low farm cost (β1 = -0.102, $p < 0.05$), maximization of profits (β1 = -0.116, $p < 0.05$), minimizing risk (β1 = -0.105, $p < 0.05$) and servicing debt (β1 = -0.060, $p < 0.05$) were found to have negatively mediating effects on run-off handling practices through attitude (i.e. least time consuming). This may be because there is little cost benefit of using sediment traps to growers in the Wet Tropics, unlike for growers in the Burdekin, who use recycle pits to recycle water (and nutrients). Results also highlighted that social motivations including time to pursue hobbies (β1 = -0.063, $p < 0.05$), being able to make own decisions (β1 = -0.182, $p < 0.05$), learning about testing new ways of doing things (β1 = -0.082, $p < 0.05$), sharing new ideas (β1 = -0.111, $p < 0.05$), and having efforts recognised by the wider community (β1 = -0.047, $p < 0.05$) also have negatively mediated relationships through attitude. All show full mediation except for 'Having time to pursue hobbies' (see Table 3).

One of the environmental goals, maintaining water supplies and storages (β1 = -0.043, $p < 0.05$), also had an impact on handling Run-off practices mediated negatively by attitudes. In addition to the 'Least time consuming' attitude, the results showed that 'Reduce business risk' attitude also mediated several hypothesised relationships. Lifestyle, economic goals, and environmental goals had an impact on run-off handling practices negatively mediated through attitude 'reduce business risk' (see Table 5).

A focus on specific behaviours related to GBR water quality may help to bridge the gap between those who do not believe their farming practices affects water quality and amongst those who may be able to take individual or collective action. The complexity of factors that affect land management practices means that no single policy instrument is likely to be universally effective (Greiner, 2014; Rolfe & Gregg, 2015). Understanding the target's lives, behaviours and sources of information and influence, for example how and whom makes decisions and both on and off farm behaviour may act as a conduit for pro-environmental behaviour change.

[2] Mediation seeks to identify and explain the mechanism or process that underlies an observed relationship between an independent variable and a dependent variable via the inclusion of a third hypothetical variable, known as a mediator variable. Full mediation would occur if inclusion of the mediation variable drops the relationship between the independent variable and dependent variable. Partial mediation maintains that the mediating variable accounts for some, but not all, of the relationship between the independent variable and dependent variable (Gunzler et al., 2013).

Table 3: Indirect Effects of Handling Run-off Practices through 'least time consuming'

Predictors (X)	Consequent										
	Run-off handling practices (Y)			Attitude towards behaviour 'Least time consuming' (M)			Indirect effect	Confidence intervals		Model Fit	Status
	Coefficient	SE	P	Coefficient	SE	P	Coefficient	LL95%CI	UL95%CI	Negalkarke R2	Level of mediation
Lifestyle											
Maintaining physical and mental health of family	0.022	0.186	0.906	252	0.241	0.299	-0.069	-0.245	0.024	0.064	NS
Maintaining family traditions and heritage	0.261	0.132	0.049	0.417	0.114	0.000	-0.145	-0.299	-0.048	0.092	Partial mediation
Spending face to face time with family	0.107	0.167	0.521	0.414	0.160	0.010	-0.119	-0.293	-0.023	0.067	Full mediation
Keeping in contact with family and friends	0.311	0.129	0.015	0.314	0.123	0.011	-0.109	-0.257	-0.019	0.106	Partial mediation
Maintaining good relations with other farmers/graziers	0.204	0.199	0.306	0.482	0.169	0.005	-0.143	-0.338	-0.035	0.071	Full mediation
Financial/economical goals											
Keeping farm cost low	0.0167	0.169	0.921	0.370	0.160	0.021	-0.102	-0.266	-0.018	0.064	Full mediation
Keeping a stable cash flow	0.094	0.187	0.614	0.264	0.220	0.231	-0.0743	-0.235	0.019	0.657	NS
Maximising farm profits	-0.015	0.200	0.938	0.425	0.189	0.026	-0.116`	-0.299	-0.019	0.064	Full mediation
Minimizing risk of very high cost or very low income	-0.045	0.162	0.783	0.389	0.159	0.015	-0.105	-0.275	-0.019	0.064	Full mediation
Servicing debt	0.008	0.117	0.941	0.208	0.121	0.086	-0.060	-0.185	-0.003	0.071	Full mediation

Table 4: Indirect Effects of Handling Run-off Practices through 'reduce business risk'

Predictors (X)	Consequent										
	Run-off handling practices (Y)			Attitude towards behaviour 'Reduce business risk' (M)			Indirect effect	Confidence intervals		Model Fit	Status
	Coefficient	SE	P	Coefficient	SE	P	Coefficient	LL95%CI	UL95%CI	Negalkarke R2	Level of mediation
Social goals											
Having time to pursue hobbies	-0.244	0.114	0.034	0.266	0.087	0.002	-0.0627	-0.1571	-0.011	0.097	Partial mediation
Being able to make your own decisions	-0.345	0.262	0.188	0.777	0.142	0.000	-0.182	-0.411	-0.032	0.077	Full mediation
Learning about testing new ways	0.086	0.183	0.638	0.294	0.189	0.121	-0.082	-0.256	-0.0006	0.065	Full mediation
Sharing new ideas with others	-0.117	0.162	0.472	0.431	0.146	0.003	-0.111	-0.287	-0.026	0.067	Full mediation
Having efforts being recognised by the wider community	-0.0281	0.914	0.758	0.184	0.078	0.019	-0.047	-0.133	-0.008	0.058	Full mediation
Environmental goals											
Maintaining water supplies and storages	0.038	0.097	0.694	0.173	0.078	0.027	-0.043	-0.119	-0.005	0.053	Full mediation
Lifestyle											
Keeping in contact with family and friends	0.2968	0.129	0.906	252	0.241	0.299	-0.069	-0.245	0.024	0.064	NS
Financial/economic goals											
Servicing debt	0.025	0.118	0.921	0.370	0.160	0.021	-0.102	-0.266	-0.018	0.064	Full mediation
Environmental goals											
Leaving the farm in better condition	0.335	0.250	0.034	0.266	0.087	0.002	-0.0627	-0.1571	-0.011	0.097	Partial mediation

Figure 2 provides an estimated model of run-off handling practices in the Wet Tropics. The dotted lines represent significant indirect relationships, Lifestyle 1: maintaining physical and mental health, Lifestyle 2: maintaining family traditions and heritage, Lifestyle 3: maintaining good relations with others, Lifestyle 4: keeping in contact with family and friends, Lifestyle 5: maintaining good relations with other farmers, Social Goals 1: being able to make own decisions, Social Goals 2: sharing new ideas with others, Social Goals 3: having efforts recognized by larger community, Social Goals 4: having time to pursue hobbies, Social Goals 5: learning about testing new ways, Financial Goals 1: keeping farm cost low, Financial Goals 2: keeping a stable cash flow, Financial Goals 3: minimizing farm profits, Financial Goals 4: minimizing risk of high cost, Financial Goals 5: servicing debt, Environmental Goals 1: maintaining and improving water supplies and storage, Environmental Goals 2: leaving the farm in better condition, Attitude towards Behaviour 1: least time consuming, Attitude towards Behaviour 2: helps reduce business risk, Perceived Norms: farmers I respect do so.

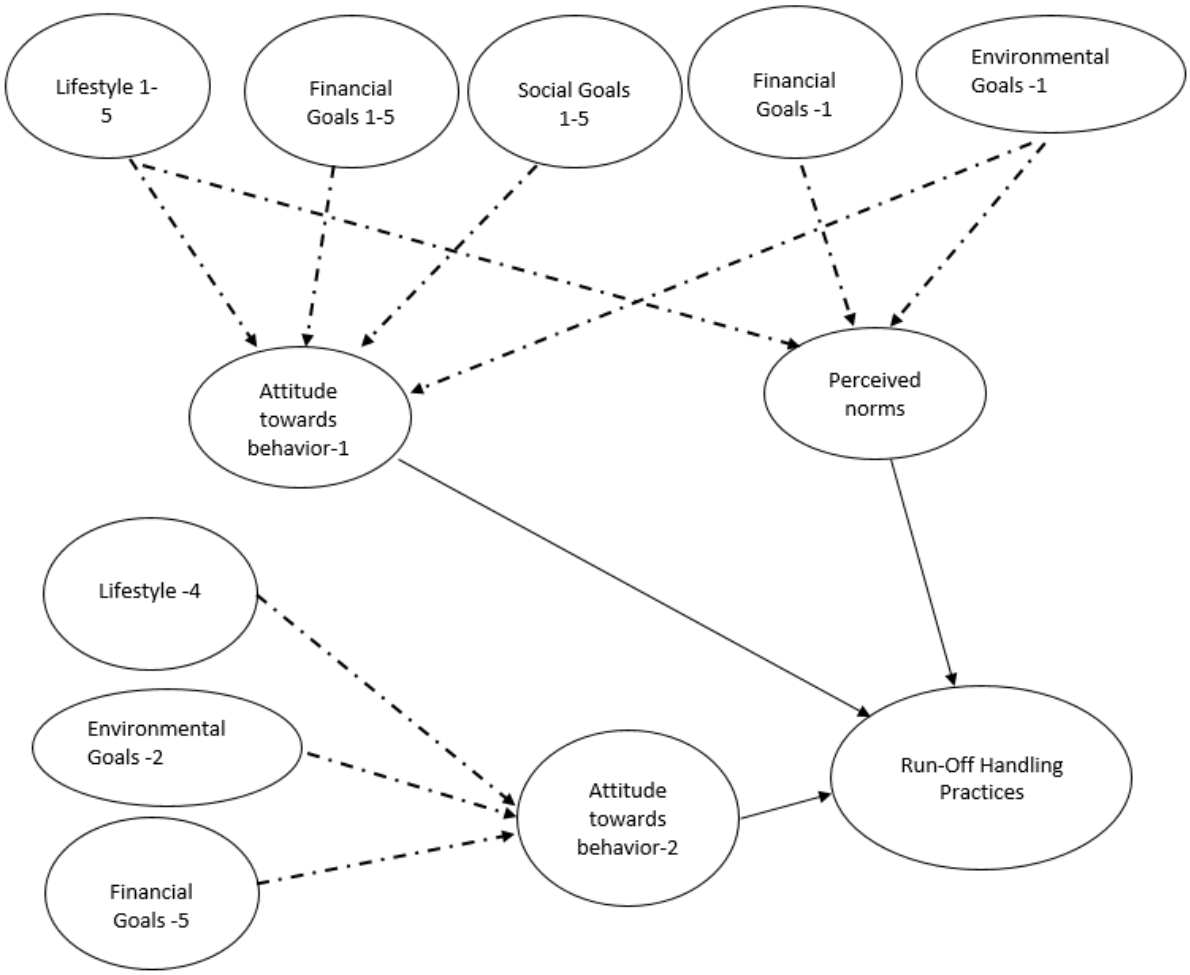

Figure 2: Estimated Model of Run-off Handling Practices, Wet Tropics

6.1.3 Recommendations

A full list of recommendations from the first round of data collection can be found in Section 8.4.

6.1.4 Limitations

See Section 5.3

6.2 Second Round (2017) Data Summary of Findings: Wet Tropics and Burdekin

Round Two data collection in the Wet Tropics area was undertaken in late 2017 (delayed from the intended July start date) with a shortened version of the questionnaires in order to focus on a small number of behavioural areas. A comparison between land managers' responses and those of extension officers and others in contact with the land managers was made. Extension officers and others were not formally surveyed during the first round data collection. The inclusion of these personnel was at the request of the Wet Tropics region NRM body in order to compare best practice perceptions and to determine whether there are substantial differences in perceptions between land managers and extension and/or advisors.

Data collection strategies were also changed for the second round. The Wet Tropics region initially agreed to collect data via an online questionnaire delivery for both land managers and extension officers. This occurred for the extension officers but the land manager data was then collected by the same extension officers through face to face interactions with the land managers. Data was directly entered into iPads and downloaded to an on-line database.

The Burdekin region NRM initially advised that they were investigating third party collection as both the quantity and quality of the first round of data in the Wet Tropics region (collected by the extension officers face-to-face), was far better, both in quantity and the quality / completeness of responses than the Burdekin region data that was collected via phone using graduate students. Second round data collection was abandoned in the Burdekin region due to a lack of time between the Round 2 and Round 3 data collection points. Instead data for the Burdekin region was only collected twice - initially in 2016 (Round 1) and again in 2018 (Round 3), therefore the Burdekin region is not reported on in this section.

6.2.1 Wet Tropics Comparison between Extension Officers and Cane Growers Decision Making Influencers and Nutrient Management Practices

This section reports on the comparison of data from extension officers and cane growers in the Wet Tropics region. The results are from the abridged version of the 2016 land manager survey (see Farr et al., 2017b) that was delivered to extension officers in the Wet Tropics region of Queensland, Australia in 2017 (Hay & Eagle, 2018). Due to the small sample size the analysis is primarily descriptive and compares responses from extension officers in 2017 to responses from land managers in 2016.

The extension officers involved in the survey were from six of the nine catchment areas of the Wet Tropics cane growing region (Hay & Eagle, 2018). The experience of extension officers varies from 1-3 years to 35+ years in the industry. The insights from the analysis follow.

Decision Making Factors

The data identified that extension officers may be underestimating the importance of land manager decision influencers, which may lead to distrust or lack of respect for the extension officer. Misunderstanding the importance of decision influencers may change the way messages are sent and received, which can significantly affect the way that messages about water quality are processed and how they influence behaviour change (Hay & Eagle, 2018, p. 11).

Grants and Funding

How extension officers perceive success and or failure in grant applications (i.e. in 2016) may present barriers or enablers for land managers who apply for grants or funding. If the land manager perceives a threat of not receiving a grant or a very low chance of success, then the land manager may not take the time to apply for any grants that are available and even if they do apply, their application may be inhibited by its perceived slim chance of success i.e. they may not put as much effort into the grant application if they perceive it is unlikely to be successful (Hay & Eagle, 2018, p. 15). This may be influenced by the type of grant or funding that the land manager applied for and the amount of obligation the extension officer has to assisting the grower, i.e. whether the onus is on the grower alone to complete the grant application or if it was a shared responsibility between grower and extension officer.

Workshops, Training Programs and Other Activities

Extension officers responded that land managers sought information about workshops, training programs and other activities from their industry extension networks, industry bodies and friends and personal networks. At the time of the survey, the workshops, training and activities were important to improving land and soil management practices to raise awareness of water quality issues as well as accreditation and networking. Extension officers thought that land managers found all workshops useful, but in particular SIX EASY STEPS, soil health workshops and SRA Masterclasses (offered to extension officers only) were identified as most valuable. Extension officers indicated that holding workshops, training and other activities outside of the harvest season, targeting skills deficiency and better coordinated systems would make the activities work better for land managers. Extension officers responded that nutrient management, soil chemistry, more involvement with extension officers and strategic coordinated extension programs with assistance from the DEHP (now DES) would help in future to assist land managers to make farm improvements (Hay & Eagle, 2018, p. 24) highlighting that the *"DEHP needs to be a presence to give the industry motivation to change"*.

Nutrient Management Practices

There are some disparities between extension officers and land managers thoughts on how land managers make decisions about nutrient management practices. When calculating fertilizer application rates, land managers rated tailoring their own fertilizer rates higher than using industry standards, while extension officers rated that they thought land managers used the same responses but in reverse. Both land managers and extension officers identified that land managers also use their advisors to calculate fertilizer application rates. Indicating with some confidence that land managers are calculating fertilizer rates using industry standards.

However, extension officer's anecdotal comments indicate that while land managers are using the industry standard (SIX EASY STEPS), they are not necessarily following protocol and hence may not be meeting the industry standard. Land managers indicated in anecdotal comments that in addition to using best management practice they are also calculating fertilizer rates based on experience, alternative methods, based on soil tests and by seeking advice from local private agronomists. The majority of farmers are using these tools to calculate fertilizer rates because their peers are also using these tools (See Hay & Eagle, 2018, p. 27 for supporting data).

Drain Management Practices

In most cases extension officers indicated that land managers in the wet tropics do not capture run-off from their farms. When they do capture run-off, they use grass headlands, drain systems, laser levelling and sediment traps or recycle pits. Only 15.8% of extension officers indicated that land managers use sediment traps, which is supported by anecdotal comments that there is a limited use of sediment traps in the wet tropics region. Land managers are influenced by other farmers when using the systems that they choose to handle run-off. Extension officers are not sure if land managers in the wet tropics can afford to use the practices available for handling run-off, but were confident that they had the technical knowledge to do so. Extension officers and land managers nominated industry extension advisors as people whose advice land mangers most frequently follow when handling run-off. The least important advisors for capturing run-off identified by extension officers were regional cane associations and Landcare (Hay & Eagle, 2018, p. 32).

Other Innovative Practices

Extension officers have identified land managers are using other innovative practices including bed renovators, contour planting, experiments with flocculants (a particle clumping substance), grassed headlands and riparian vegetation, wet land bioreactors (a natural water purification process), sediment traps, minimum tillage, wetlands, spoon drains, subsurface fertilizer application, headland management, well designed drainage, trash blanketing and spraying out and covering fallowed fields. One extension officer stated that "*the innovation is about minimising the amount of sediment, DIN and chemicals, which is about placement, timing, farming systems; there are plans to intercept groundwater DIN using filters*" as a solution to reducing run-off (Hay & Eagle, 2018, p. 36).

Perceptions of Causes and Pressure on Water Quality

Extension officers agreed (84.2%) with the statement that nutrient losses from cane growing are having an effect on the water quality of local streams, rivers and waterways. However land managers (42%) disagreed, responding that cane growing has no effect on the water quality of local streams, rivers and waterways. By contrast, while 30% of land managers believe that their activities are negatively affecting water quality, none of the extension officers believe that land managers take this view. Just under 13% of land managers were unsure and 15% took a neutral stance about nutrient losses affecting water quality and a small percent of extension officers nominated that they didn't know if cane farming has an impact on water quality.

A more detailed analysis is contained in the Report, *Land Managers Decision Making about Water Quality: Views from Extension Officers of the Wet Tropics, Queensland, Australia* (Hay & Eagle, 2018).

6.2.2 Recommendations

A full list of recommendations from the second round of data collection can be found in Section 8.5.

6.2.3 Limitations

While the sample size represents 100% of extension officers invited to complete the survey (N=31), the sample was restricted to one single cane growing region (the Wet Tropics) in North Queensland. Therefore, the results may not be representative across all cane growing regions.

The potential for voluntary response bias is also acknowledged, where there is overrepresentation of individuals that have strong opinions about extension activities. However, it should be noted that such bias is normatively defensive because the second round of the study has occurred within the explicitly extension officer group and that the research has been conducted without concealment or fabrication (MacCoun, 1998).

6.3 Third Round (2018) Data Summary of Findings: Comparison between first round (2016/17) and third round (2018) Data

Round Three data was collected in both the Wet Tropics and the Burdekin regions. Third round data collection for both regions was undertaken from May to August 2018 repeating the original full length survey (see Farr et al., 2016 for details of the questionnaire).

6.3.1 Wet Tropics Sugar Cane Nutrient and Run-off Management Practices, Results from Round 3 Land Managers Survey

The Wet Tropics region survey was delivered face-to-face to land managers by extension officers and the data was directly entered into iPads using Qualtrics Survey Software. In addition thirty-six surveys were manually completed during face-to-face interviews and the data was entered to the online database by a university research assistant. The data was cleaned (words changed to numbers, ages grouped and anecdotal comments coded, etc.) and imported to SPSS for analysis. A total of 118 surveys were collected in 2018. In 2017, 248 surveys were completed bringing the total number of surveys to 366.

Data from the first round (2016/17) of the Wet Tropics survey was compared with the third round (2018) of Wet Tropics survey results to determine if there were any changes to behaviour or attitude towards improving nutrient and run-off practices for improved water quality in the GBR Basin. Below are the results from questions related to nutrient and run-off management practices, results from structural equation modelling are presented in Section 5.3.

6.3.1.1 Factors that influence land manager decisions

In order to understand the factors that influence their decisions, land managers were asked to identify the two most important things that they hoped to achieve for their farm or property.

Land managers responses were coded into first round and third round data, which resulted in the same goals over the duration of the study. Land managers main goals are to improve their land so that it can remain productive and sustainable into the future, while focussing on maintaining their level of stewardship, highlighting a motivation to participate in good farming practices.

Table 5: Wet Tropics land managers personal goals to achieve on farm/property

Goal 1	Goal 2
To leave the farm in a financial and sustainable position	Leave farm in a better condition than when we started farming 40 years ago
Improve production and quality of cane	Pass property on to children in good condition
To grow a healthy efficient crop	Maintaining the environment (stewardship of the land) maintain/increase soil health

6.3.1.2 Decision making drivers

The next question asked land managers how important they thought a set of 21 statements were when making decisions about what to do on their farm or property (See Table 6). The same set of questions were asked about three different practices. The participants were asked to choose the importance of each statement on a scale of 1-extremely unimportant to 8 where 7 was equal to extremely important (essential) and 8 was equal to 'I don't know', the number 4 was listed as neutral. A means test was applied to compare first and third round land manager responses, followed by an independent samples t-test to establish any significant difference in the responses.

Family, friends and other land manager influences

The first set of statements considered family, friends and other land manager influences when making decisions. While all of the statements were indicated as important only 'maintaining family traditions and heritage' (first round M=6.13, SD=0.88) and third round M=5.85, SD=1.05; t(315)=2.34, p=.02, two tailed) and 'maintaining good relations with other farmers/graziers in the local area' (first round M=5.64, SD=1.30 and third round M=5.27, SD=1.47; t(314)=2.08, p=.03, two tailed) were statistically significant. Analysis of first round data found that 'maintaining good relations with other farmers/graziers in the local area' was important but not significant (see Farr et al., 2016; Farr et al., 2017b for results). The current results may indicate the respondents have changed the way they maintain relationships with other farmers or graziers. There was no significant difference between the other means.

Financial influencers

Similarly, all of the statements that considered financial influences were indicated as important. 'Maximising farm profits' was rated as a somewhat important influencer in both the first round (M=6.53, SD=0.85) and the third (M=6.55, SD=0.79) round of data collection, when making decision about land management on the farm or property. However, while 'servicing debt' first round (M=6.10, SD=1.40) and the third round (M=5.80, SD=1.42) was indicated as less important than maximising farm profits, there was a higher agreeance that 'servicing debt' was still an important influencer to decisions about land management. An independent t-test found no significant difference between scores from first round data to scores from third round data indicating that maximising farm profits and servicing debt are ongoing influencers when making decisions about what to do on the farm/property.

Land managers making their own decisions, testing and sharing new ideas and having time to pursue hobbies when making decisions about the farm/property

The next set of statements provide land manager responses about making their own decisions, testing and sharing new ideas and having time to pursue hobbies when making decisions about the farm/property. While all of the statements were indicated as important, 'having efforts recognised by the wider community' (first round M=4.67, SD=1.72 and third round M=5.10, SD=1.45; t(315)=-1.92, p=.05, two tailed) and 'sharing new ideas with others' (first round M=5.97, SD=1.09) and third round M=5.65, SD=1.21; t(107)=2.00, p=.05, two tailed) were statistically significant. While 'having efforts recognised by the wider community' was the least important factor for both rounds of data collection, the factor was considered more important in the third round of data collection. Similarly, the results indicate that the importance of 'sharing new ideas with others' has slightly increased as an influencer when making decision about what to do on the farm/property. There was no significant difference between the other means across the two data collection periods.

Land management influencers

The next set of statements consider land management influences when making decisions. While all of the statements were indicated as important 'minimising sediment run-off and/or nutrient losses' scores (first round M=6.55, SD=.77) and third round M=6.32, SD=0.95; t(312)=2.05, p=.04, two tailed) was significant, indicating that minimising run-off has increased in importance between first round and third round data collection. There was no significant difference between the other means across the two data collection periods.

Farming practices

Land managers rated 'leaving the land in better condition than it was when they first started managing it' and 'maintaining and improving water supplies and storages' were rated as important to extremely important to land managers when making decisions on their property. However, there was no statistical difference in importance between the first round and the third round of data collection. Whereas there was a statistical difference for minimising sediment run-off and or nutrient losses between first round (M=6.55; SD=0.77) and third round data (M=6.32, SD=0.95; t(312)=2.61, p=.04, two tailed), where land managers rated it as important to making decisions in the third round of data collection as they did in the first round.

Safeguarding local waterways, native plants and animals and the Great Barrier Reef

The final set of statements indicate that safeguarding local waterways, the Great Barrier Reef (GBR) and native plants and animals are important to land managers. While land managers highly agree with safeguarding native plants and animals, it was less important than safeguarding local waterways and the GBR. An independent t-test highlighted a significant difference for 'helping to safeguard local waterways' scores for first round (M=6.40, SD=.89) and third round (M=6.07, SD=1.11; t(313)=2.57, p=.01, two tailed). The magnitude of difference in the means (mean difference = .31, 95% CI: .08 to .54) was small to moderate (eta squared = .021). Similarly, an independent t-test highlighted a significant difference for 'helping to safeguard the GBR' scores for first round (M=6.42, SD=.81) and third round (M=6.11, SD=1.08; t(313)=2.61, p=.01, two tailed). The magnitude of difference in the means (mean difference = .32, 95% CI: .08 to .58) was also small to moderate (eta squared = .021). Both results indicate that safeguarding local waterways and the GBR are important influencers when land managers are making decisions about what to do on their farm/property.

Table 6: Wet Tropics land manager responses decision making drivers

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
Maintaining physical and mental health of family	246	6.59	0.86	71	6.41	1.09
Spending face-to-face time with family and friends	246	6.19	1.01	71	6.11	1.01
Maintaining good relations with other farmers/graziers in the local area*	246	6.13	0.88	71	5.85	1.05
Keeping in contact with family and friends in other ways (e.g. via phone, through social media)	243	5.79	1.35	71	5.46	1.26
Maintaining family traditions and heritage*	245	5.64	1.30	71	5.27	1.47
Maximising farm profits (income minus costs)	245	6.53	0.85	71	6.55	0.79
Keeping a stable (steady) cash-flow	246	6.48	0.87	71	6.48	0.75
Keeping farm costs low	246	6.43	0.95	71	6.38	0.99
Minimising risk (of very high costs or very low income)	246	6.26	1.01	71	6.34	0.92
Servicing debt	240	6.10	1.40	71	5.80	1.42
Being able to make your own decisions about your farm/property	246	6.59	0.79	71	6.56	0.71
Learning about and testing new ways of doing things on your farm/property	246	6.23	0.86	71	6.14	0.87
Sharing new ideas with others*	246	5.97	1.09	72	5.65	1.21
Having time to pursue hobbies	246	5.23	1.49	71	5.39	1.37
Having efforts recognised by the wider community*	245	4.67	1.72	72	5.10	1.45
Leaving the land/farm in better condition than it was when you first started managing it	245	6.59	0.76	71	6.65	0.61
Minimising sediment run-off and/or nutrient losses*	243	6.55	0.77	71	6.32	0.95
Maintaining/improving water supplies and storages	206	5.99	1.73	72	5.93	1.71
Helping to safeguard local waterways*	243	6.42	0.81	72	6.11	1.08
Helping to safeguard the Great Barrier Reef*	243	6.40	0.89	72	6.07	1.10
Helping to safeguard native plants and animals	242	5.99	1.04	72	5.76	1.24
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

6.3.1.3 Nutrient Management Practices

Land managers were asked to answer a series of questions about their nutrient management practices. The responses from the first round of data were compared to responses from the third round of data to identify any changes in nutrient management practices.

Calculating Fertiliser Application Rates

When asked how the respondents calculate their fertiliser application rates, the majority in both first and third round data collection selected that they tailor their fertiliser rates to different parts of the property (see Table 7). Just over one quarter of respondents in the first round and one quarter of respondents in third round tailor fertiliser rates to different parts of their property.

There is a slight increase in participants that are using industry standards in the third round of data collection compared to the first round. Twenty percent in the first round and 16% in the

second round of data collection do something else (Other) to calculate their fertiliser application rates (see Table 8).

The remaining respondents in each year are estimating fertiliser rates from farm yield or they are applying more or less depending on performance of the block. Nearly one quarter of respondents in the first round of data collection and 30% of respondents in the third round selected that their advisor calculates fertiliser application rates for them.

Table 7: Wet Tropics participant responses to the question 'How do you calculate fertiliser application rates?"

	1st Round		3rd Round	
	n	Percent	n	Percent
I tailor my fertiliser rates to different parts of the property	133	28.7	40	25.6
My advisor does this for me**(Table 9 below)	114	24.6	46	29.5
Other. Please tell us what you do*(Table 8 below)	97	21.0	25	16.0
I use industry standard rates for district yield potential, and use that amount on all parts of my farm	96	20.7	34	21.8
I estimate amounts from my farm yield and use that amount on all parts of my farm	13	2.8	5	3.2
I use more fertiliser on under-performing (low yield) blocks than on other blocks	7	1.5	2	1.3
I use more fertiliser on high – performing (high yielding) blocks	3	0.6	4	2.6
Total	**462**	**100**	**156**	**100**

The responses from 'Other. Please tell us what you do' in Table 7 above were coded into ten themes, see Table 8 below. More land managers were using six easy steps to calculate their fertiliser application rates as an alternative measure for fertiliser application in first round data collection (47.4%) than in third round (36.0%). This is reflective of the six easy steps workshops attended by more land managers in the first round of data collection than in the third round. Land managers were using experience or historical data more in the first round of data collection than in the third round, which may indicate a change in activities more in line with best management practice. Less land managers reported using 'Other' ways to calculate fertiliser application rates, such as soil tests, genetic evaluation systems and nutrient management plans are decreasing as an alternative, whereas using best management practices, mill mud, organic matter or alternative crops has increased. Thirty two percent of land managers who nominated that they use an 'Other' way to calculate fertiliser application rates are using Smartcane BMP and 16% are using mill mud, organic matter or alternative crops as part of their fertiliser application management, indicating a change in the way that fertiliser application rates are calculated.

Table 8: Wet Tropics land manager responses to 'How do you calculate fertiliser application rates? - Other'

Other. Please tell us what you do*	1st Round		3rd Round	
	n	Percent	n	Percent
6 Easy Steps	46	47.4	9	36.0
Experience/Historical	13	13.4	0	0.0
Soil Tests	12	12.4	1	4.0
GES (Genetic Evaluation System)	11	11.3	1	4.0
Agronomist	4	4.1	0	0.0
Mill mud/ Organic Matter/Alternative Crops	3	3.1	4	16.0
Smartcane BMP	2	2.1	8	32.0
Variable rate box	2	2.1	2	8.0
Nutrient Management Plan	1	1.0	0	0.0
Other*	3	3.1	0	0.0
Total	**97**	**100**	**25**	**100**
**Experimental low rates using biology; For planting the compactor puts on the same rate across the property; I trail the ratoon rate; Tailor to different varieties*				

To establish who their advisor was (Table 7 above), for those land managers who selected that their 'My advisor does this for me' a cross tabulation between 'advice land managers follow most when calculating fertiliser rates' and 'how do you calculate fertiliser application rates - my advisor does this for me was performed (see Table 9). In both first and third round data collection, the land manager's main advisor was industry extension advisors, followed by private agronomists and researchers.

Table 9: Cross tabulation of Wet Tropics land managers 'Advice land managers follow most when calculating fertiliser rates' and 'how do you calculate fertiliser application rates - my advisor does this for me'

Advice followed most when calculating fertiliser rates - who?	My advisor does this for me			
	1st Round		3rd Round	
	n	Percent	n	Percent
Industry extension advisors (e.g. from SRA [BSES], Production Boards, Productivity Services group)	48	45.7	18	38.3
Private Agronomists	23	21.9	18	38.3
Researchers	8	7.6	4	8.5
Family who are also cane farmers	4	3.8	2	4.3
Other extension officers. From where?	4	3.8	1	2.1
Cane Growers (the organisation)	3	2.9	0	0.0
Other cane farmers	1	1.0	0	0.0
Landcare	1	1.0	1	2.1
Regional cane association (e.g. from Kalamia, Invicta, Inkerman, Tully Sugar)	0	0.0	0	0.0
People from NQ Dry Tropics/TERRAIN	0	0.0	1	2.1
Other. Who?*	13	12.4	2	4.3
Total	**92**	**100**	**45**	**100**

Where land managers nominated an 'Other. Who?' (Table 10) as advice they follow when calculating fertiliser rates, they nominated fertiliser companies and resellers, their own experience and advice from best management practices in both rounds of data collection as 'other' advice land managers follow.

Table 10: Advice followed most when calculating fertiliser rates - *Other. Who?

Advice followed most when calculating fertiliser rates - *Other. Who?	1st Round		3rd Round	
	n	Percent	n	Percent
Fertiliser Company/Reseller	47	64.4	12	66.7
Myself (Experience & Knowledge)	19	26.0	4	22.2
Best Practice Management (6ES, Smartcane [BMP modules], Soil Tests)	4	5.5	2	11.1
Extension Staff	2	2.7	0	0.0
Financial Constraints	1	1.4	0	0.0
Total	**73**	**100**	**18**	**100**

Table 10 'Other. Who?' indicates that more than 60% of land managers in both first and third year data collection nominated fertiliser resellers as the advisor they follow most when calculating fertiliser rates. This finding highlights fertiliser resellers as highly influential to land managers when making decisions about calculating fertiliser rates. Anecdotal comments from land managers (and extension officers) during the study period have confirmed this influence as a reason for not following best management practice in fertiliser application. Several land managers (and extension officers) have also stated that land managers will ignore best management practice if the reseller incentivises fertiliser purchases e.g. buy two tonnes of fertiliser and get one tonne free.

Advice land managers follow most when calculating fertiliser application rates

Land managers were asked to rank from 1= most important to 12=least important whose advice they follow most when calculating fertiliser application rates. A cross tabulation between 'advice land managers follow when calculating fertiliser rates' and 'round of data collection' compared responses from the first and third rounds of data collection (see Table 11 and Table 12).

In the first round data collection, land managers found advice from industry extension most important, followed by private agronomists, other – who?*, researchers then family who are also cane farmers. The 'Other. Who?' selection highlights that land managers found advice important from their own experience, fertiliser companies and resellers, best management practice, from local agronomists or agricultural productivity boards and through financial and/or environmental constraints. 'Other extension officers, from where?' also highlights resellers, government agency and mills as important advisors. 'People from government departments, which departments?' are highlighted as being primarily from the Department of Agriculture and Fisheries (DAF).

Table 11: Advice Wet Tropics land managers follow when calculating fertiliser rates, ranked 1 most important to 12 least important – 1st Round Data Collection

Advisor	1st Round												
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Industry extension advisors (e.g. from SRA [BSES], Production Boards, Productivity Services group)	110	43	11	7	2	0	0	1	0	0	0	0	**174**
Private Agronomists	38	29	19	4	7	2	0	0	0	0	0	0	**99**
Other. Who?*	31	23	6	4	1	0	0	0	0	0	0	1	**66**
Researchers	18	22	17	13	9	0	1	0	1	0	0	0	**81**
Family who are also cane farmers	13	20	13	6	5	1	0	1	0	0	0	0	**59**
Other extension officers. From where?**	8	15	8	8	8	0	1	0	0	1	3	0	**52**
Other cane farmers	6	20	35	12	11	1	1	0	0	1	0	0	**87**
Cane Growers (the organisation)	5	9	14	19	13	0	1	0	1	0	0	0	**62**
People from government departments. Which departments?***	1	2	6	3	4	1	0	1	1	2	1	2	**24**
Landcare	1	1	1	0	3	1	0	1	0	2	0	0	**10**
People from NQ Dry Tropics/TERRAIN	0	2	3	3	2	0	1	0	1	1	1	0	**15**
Regional cane association (e.g. from Kalamia, Invicta, Inkerman, Tully Sugar)	0	0	2	0	0	1	1	1	1	1	0	0	**7**

**Other. Who? (Number of responses): their own experience (52), fertiliser companies and resellers (12), best management practice (7), from local agronomists (1) and through financial and/or environmental constraints (1)*
***Other Extension, from where: Resellers (14), Government: DAFF, DPI (14), Mill (10), productivity board/Industry (8), best management practice, (1), agronomist (1), and researcher (1).*
**** Government Departments: DAF (7), DPI (2), DERM (1), DSITI (1), DIS (1), EHP (1), and SRA (1)*

In the third round data collection, land managers also placed the most importance on industry extension officers in the first instance, then researchers, private agronomists, Cane Growers (the association) and other cane farmers. 'Other. Who?' also highlighted fertiliser companies and resellers, land manager own experience, local agronomists and productivity boards as advisors that they follow most. 'Other extension, from where?' and 'People from government departments. Which departments?' responses are similar to first round data collection (see Table 12).

Table 12: Advice Wet Tropics land managers follow when calculating fertiliser rates, ranked 1 most important to 12 least important – 3rd Round Data Collection

Advisor	3rd Round												
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Industry extension advisors (e.g. from SRA [BSES], Production Boards, Productivity Services group)	46	16	14	9	6	1	0	3	0	4	1	0	**100**
Researchers	10	22	14	11	3	2	4	3	8	7	3	2	**89**
Private Agronomists	29	10	7	8	6	1	3	8	10	1	1	0	**84**
Cane Growers (the organisation)	2	7	12	14	8	17	15	3	2	0	0	1	**81**
Other cane farmers	1	8	20	13	10	11	4	5	5	2	0	1	**80**
Family who are also cane farmers	7	18	4	8	14	9	9	2	2	0	2	1	**76**
Other extension officers. From where?**	3	11	10	2	5	6	4	1	3	4	25	2	**76**
Other. Who?*	7	7	5	5	9	2	3	5	7	4	2	18	**74**
Landcare	1	1	3	0	1	4	1	8	9	32	14	0	**74**
People from government departments. Which departments?***	0	0	1	4	0	4	1	5	4	7	7	41	**74**
People from NQ Dry Tropics/TERRAIN	1	1	1	1	6	9	7	18	10	7	11	1	**73**
Regional cane association (e.g. from Kalamia, Invicta, Inkerman, Tully Sugar)	1	1	3	7	7	7	19	8	10	2	3	2	**70**

**Other. Who? (Number of responses): fertiliser companies and resellers (9), their own experience (6), from local agronomists (2) and through agricultural productivity boards (1)*
***Other Extension, from where: Extension officer (7), productivity board/Industry (4), mill (3), resellers (2), and Government: DAFF, DPI (2).*
**** Government Departments: DAF (2), DoE (1), DIS (1), and EHP (1)*

Regional cane associations, Landcare, people from government departments and people from natural resource management groups were nominated as least important to follow advice in both first round and third round data collection (see Table 11 and Table 12).

It is important to note the high influence that networks have on land manager decisions, as they may identify barrier to practice change. The findings support previous recommendations for a land manager network analysis to ensure that information gatekeepers and opinion leaders influence future water quality communication strategies (see Hay & Eagle, 2018).

Attitudes and motivations associated with calculating fertiliser application rates

The next question asked participants how important they thought a set of listed statements were to land managers when making decisions about calculating fertiliser rates. The participants were asked to choose the importance of each statement on a scale of 1-strongly disagree to 7 strongly agree, with 4 being neutral.

The first set of statements considered decision influencers when making decisions about calculating fertiliser rates. The data indicates that land managers decisions are somewhat influenced by 'farmers they respect' with regard to fertiliser rate calculations in both first (M=5.77, SD=1.73) and third round (M=5.03, SD=1.68) data. The respondents somewhat disagree in both first round (M=3.64, SD=2.37) and third round (M=3.38, SD=2.22), that other land managers in the area would not have the technical knowledge to calculate fertiliser rates. However, a large percentage (60%) use resellers to calculate their fertiliser rates (see Table 9), therefore this may not truly reflect the confidence of the land managers to calculate fertiliser rates. Land managers disagreed in both first round (M=2.66, SD=2.26) and third round (M=2.84, SD=2.25) data collection that land managers in the region would not be able to afford to use the systems to calculate fertiliser rates, indicating that the systems mentioned are affordable. Land managers also did not agree that they were being forced to use the methods, see Table 13. There were no significant difference in scores for each statement.

Table 13: Wet Tropics land manager attitudes and motivations associated with calculating fertiliser application rates

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
The farmers I respect most do this	221	5.77	1.73	69	5.93	1.68
Most farmers in this region would not have the technical knowledge to do this	213	3.64	2.37	69	3.38	2.22
Most farmers in this region would not be able to afford to use this system for calculating fertiliser rates	214	2.66	2.26	69	2.84	2.25
I only do this because I am forced to. Who/what is forcing you?	212	2.05	1.92	69	2.12	1.73
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

The second set of statements ask the land manager to read the statement and respond how using their method for calculating fertiliser rates measures when compared to other ways of calculating fertiliser rates.

While all statements have high agreement (see Table 14) 'the best way to meet my own personal goals' and to be 'the least time consuming' compared to other ways of calculating fertiliser rates are the most significant motivators for using the method that the land manager is using. It is interesting to note that in the third round of data collection land managers were more neutral (M=4.96, SD=1.81) about their way of calculating fertiliser rates being 'the least time consuming' than the first round (M=5.50, SD=1.55). This may be due to increased awareness of growers' legal obligations towards best management practices, given that 32% of land managers are using Smartcane BMP in the third round of data collection compared to 2.1% in the first round of data collection.

Table 14: Compared to other ways of calculating fertiliser rates, what motivates Wet Tropics land managers to use the system that they use?

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
The best way to meet my own personal goals*	217	6.26	1.04	69	5.96	1.27
The most effective way of controlling nutrient loss from my property	218	6.24	1.16	69	6.12	1.19
The best way to maintain good cash-flow	219	6.17	1.04	69	5.88	1.16
The best way to reduce business risk	218	6.16	1.07	69	5.93	1.13
The least time-consuming (or labour intensive)*	218	5.50	1.55	69	4.96	1.81
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

An independent t-test highlighted a significant difference for 'the best way to meet my own personal goals' scores for first round (M=6.26, SD=1.04) and third round (M=5.96, SD=1.27; t(284)=2.02, p=.04, two tailed). The magnitude of difference in the means (mean difference =.30, 95% CI: .01 to .61) was small (eta squared =.01). The result indicates that while, calculating fertiliser rates to meet the land managers own personal goals had decreased in importance between first round and third round data collection, only 1% of the variance was explain by time between the data collection points. The effect was similar for 'the least time consuming' factor. There was no significant difference between the other means across the two data collection periods.

Has calculating fertiliser application rates changed?

To establish whether there was a change in the way land managers calculate fertiliser application rates between first and third round data collection, a multiple response cross-tabulation was performed (see Table 13). The land manager unique identification number was used to identify growers in each round of data collection (1=Grower First Round and 3=Same Grower Third Round). There were 111 growers who responded to the statements in first round and 93 who responded in the third round of data collection. Results in Table 15 indicate that there has been a change in the way land managers calculate fertiliser application. For example 28% of third round land managers are using industry standard rates for district yield potential compared to first round land managers (17.1%).

Table 15: Comparison between 'How first and third round Wet Tropics land managers calculate fertiliser application rates'

How do you calculate fertiliser application rates?		Have you completed this survey before?		
		Grower 1st Round	**Same Grower 3rd Round**	**Total**
I use industry standard rates for district yield potential, and use that amount on all parts of my farm	Count	19	26	45
	% within $FAPP	42.2%	57.8%	
	% within CompBefore	**17.1%**	**28.0%**	
	% of Total	9.3%	12.7%	22.1%
I use more fertiliser on high – performing (high yielding) blocks	Count	0	4	4
	% within $FAPP	0.0%	100.0%	
	% within CompBefore	**0.0%**	**4.3%**	
	% of Total	0.0%	2.0%	2.0%
I estimate amounts from my farm yield and use that amount on all parts of my farm	Count	3	4	7
	% within $FAPP	42.9%	57.1%	
	% within CompBefore	**2.7%**	**4.3%**	
	% of Total	1.5%	2.0%	3.4%
My advisor does this for me	Count	30	32	62
	% within $FAPP	48.4%	51.6%	
	% within CompBefore	**27.0%**	**34.4%**	
	% of Total	14.7%	15.7%	30.4%
I use more fertiliser on under-performing (low yield) blocks than on other blocks	Count	6	2	8
	% within $FAPP	75.0%	25.0%	
	% within CompBefore	**5.4%**	**2.2%**	
	% of Total	2.9%	1.0%	3.9%
I tailor my fertiliser rates to different parts of the property	Count	53	25	78
	% within $FAPP	67.9%	32.1%	
	% within CompBefore	**47.7%**	**26.9%**	
	% of Total	26.0%	12.3%	38.2%
Total	**Count**	**111**	**93**	**204**
	% of Total	**54.4%**	**45.6%**	**100.0%**

Percentages and totals are based on responses.
a. There are not enough (less than 2) multiple response groups for pairing. Percentages are based on responses, but no pairing is performed.
b. Dichotomy group tabulated at value 1.

While none of the land managers reported using more fertiliser on high yielding blocks in first round data, 4.3% of land managers reported using this technique to calculate fertiliser application in the third round. Similarly, third round land managers (4.3%) are estimating amounts from their farm yield and then using that amount on all parts of their farm.

A slightly higher proportion of third round land managers (34.4%) are using their advisor to calculate fertiliser rates than first round land managers (27%). By contrast, less third round land managers (2.2%) are using more fertiliser on low yielding blocks than on other blocks than first round land managers (5.4%). A lower proportion of third round land managers (26.9%) are tailoring their fertiliser rates to different parts of their property compared to first round land managers (47.7%). While the data in Table 15 indicates changes in the way that

land managers are calculating their fertiliser application rates, the results cannot determine if land managers are using best practice management techniques to calculate fertiliser rates or some other method.

6.3.1.4 Run-off Management Practices

Land managers were asked to answer a series of questions about their run-off management practices. The responses from the first round of data were compared to responses from the third round of data to identify any changes in run-off management practices.

Handling run-off

A multiple response analysis indicates that nearly one third of land managers are following conventional run-off management practices such as using recycle pits and sediment traps and one third are using the superseded or outdated practice of not capturing run-off. However, this may be due to identifying run-off as being from irrigation which is not widely used in the wet tropics. Less than 1% of land managers are using their recycle pits with adequate pumping capacity to recycle water. Other practices are either meeting minimum expectations or are current practices as promoted by the industry (ABCD Framework, Drewry, Higham, & Mitchell, 2008; Trendell, 2013) (see Table 16).

Table 16: Wet Tropics land manager responses to the question 'how do you handle run-off from rainfall or irrigation?'

	ABCD Framework	**1st Round**		**3rd Round**	
		n	Percent	n	Percent
I have recycle pits/Sediment traps	C	99	29.9	4	3.8
I do not capture run-off	D	93	28.1	11	10.6
I have recycle pits and have adequate pumping capacity to recycle the water	B	3	0.9	7	6.7
Other. Please tell us what you do*	C-B	136	41.1	82	78.8
Total		**331**	**100**	**104**	**99.9**
	ABCD Framework	**1st Round**		**3rd Round**	
Other*		n	Percent	n	Percent
Sediment trap	C	13	9.6	11	13.4
Grass and Drains	C-B	53	39.0	45	54.9
Buffer Zones/Riparian Boundary/Revegetation	C-B	17	12.5	7	8.5
Contouring	C-B	7	5.1	4	4.9
Laser levelled, silt trap, grass	C-B	6	4.4	7	8.5
Grass and trash blanket	C	26	19.1	4	4.9
Natural drainage filter	C-B	6	4.4	1	1.2
Rock walls	C-B	4	2.9	0	0.0
Other**	C-B	4	2.9	3	3.7
Total		**136**	**100**	**82**	**100**

***First Round: Do not irrigate + have 1 metre+ rainfall, below sea level/next to subdivision - run-off is heavy due to streets and houses, timing of cultivation, using subsurface + liquid fertiliser that slows down N losses. Third Round: controlled drops from headland to drains, natural bio-reactors, I carefully control run-off from within & from paddocks*

Advice land managers follow most when handling run-off

Land managers were asked to rank from 1= most important to 12=least important whose advice they follow most when handling run-off. A cross tabulation between 'advice land managers follow when handling run-off' and 'round of data collection' compared responses from the first and third rounds of data collection (see Table 17 and Table 18).

In the first round of data collection, industry extension officers, private agronomists and other (includes their own experience, fertiliser resellers and best management practice) rank the highest form of advice that was followed by land managers who grow sugar cane in the Burdekin. Regional cane associations, people from NRMs and Landcare ranked the lowest form of advice followed in the first round of data collection.

Table 17: Advice Wet Tropics land managers follow when handling run-off, ranked 1 most important to 12 least important – 1st Round Data Collection

Advisor	**1st Round**												
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Industry extension advisors (e.g. from SRA [BSES], Production Boards, Productivity Services group)	110	43	11	7	2	0	0	1	0	0	0	0	**174**
Private Agronomists	38	29	19	4	7	2	0	0	0	0	0	0	**99**
Other. Who?	31	23	6	4	1	0	0	0	0	0	0	1	**66**
Researchers	18	22	17	13	9	0	1	0	1	0	0	0	**81**
Family who are also cane farmers	13	20	13	6	5	1	0	1	0	0	0	0	**59**
Other extension officers. From where?	8	15	8	8	8	0	1	0	0	1	3	0	**52**
Other cane farmers	6	20	35	12	11	1	1	0	0	1	0	0	**87**
Cane Growers (the organisation)	5	9	14	19	13	0	1	0	1	0	0	0	**62**
People from government departments. Which departments?	1	2	6	3	4	1	0	1	1	2	1	2	**24**
Landcare	1	1	1	0	3	1	0	1	0	2	0	0	**10**
People from NQ Dry Tropics/TERRAIN	0	2	3	3	2	0	1	0	1	1	1	0	**15**
Regional cane association (e.g. from Kalamia, Invicta, Inkerman, Tully Sugar)	0	0	2	0	0	1	1	1	1	1	0	0	**7**

**Other. Who? (Number of responses): their own experience (52), fertiliser companies and resellers (12), best management practice (7), agronomist (1) and from financial or environmental constraints (1)*

***Other Extension, from where: reseller/fertiliser supplier or company extension officer (14), Government agency extension officer (14), mill (10), agricultural productivity board/industry (8), agronomist (1) researcher (1).*

**** Government Departments: DAF/DPI (7), DERM (1), DSITI (1), SRA(1)*

Similarly, in the third round of data collection industry extension, private agronomists and researchers were ranked as most important as advisors. However, family who are also cane

farmers was ranked as more important in third round than in the first round of data collection. While people from government departments was ranked 9th in the first round of data collection, they were ranked 12th in the third round, indicating a change in trust of advice from people in government departments. However, on an individual level in the first round, people from government departments were ranked as the third most followed advisor, see Table 17.

Table 18: Advice Wet Tropics land managers follow when handling run-off, ranked 1 most important to 12 least important – 3rd Round Data Collection

Advisor	**3rd Round**												
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Industry extension advisors (e.g. from SRA [BSES], Production Boards, Productivity Services group)	46	16	14	9	6	1	0	3	0	4	1	0	**100**
Private Agronomists	29	10	7	8	6	1	3	8	10	1	1	0	**84**
Researchers	10	22	14	11	3	2	4	3	8	7	3	2	**89**
Family who are also cane farmers	7	18	4	8	14	9	9	2	2	0	2	1	**76**
Other. Who?	7	7	5	5	9	2	3	5	7	4	2	18	**74**
Other extension officers. From where?	3	11	10	2	5	6	4	1	3	4	25	2	**76**
Cane Growers (the organisation)	2	7	12	14	8	17	15	3	2	0	0	1	**81**
Other cane farmers	1	8	20	13	10	11	4	5	5	2	0	1	**80**
Landcare	1	1	3	0	1	4	1	8	9	32	14	0	**74**
People from NQ Dry Tropics/TERRAIN	1	1	1	1	6	9	7	18	10	7	11	1	**73**
Regional cane association (e.g. from Kalamia, Invicta, Inkerman, Tully Sugar)	1	1	3	7	7	7	19	8	10	2	3	2	**70**
People from government departments. Which departments?	0	0	1	4	0	4	1	5	4	7	7	41	**74**

**Other. Who? (Number of responses): their own experience (6), fertiliser companies and resellers (9), agronomist (2) and from agricultural productivity board (1)*
***Other Extension, from where: reseller/fertiliser supplier or company extension officer (2), Government agency extension officer (2), mill (3), agricultural productivity board/industry (4), BMP (1), agronomist (1) extension officer (7).*
**** Government Departments: DAF (2), DoE (2), DIS (1)*

Attitudes and motivations associated with handling run-off

The next question asked participants how important they thought a set of listed statements were to land managers when making decisions about handling run-off. The participants were asked to choose the importance of each statement on a scale of 1-strongly disagree to 7 strongly agree, with 4 being neutral.

The first set of statements considers influences when making decisions about handling run-off. The data indicates that land managers agree that their decisions are influenced by 'farmers they respect' with regard to handling run-off in both first (M=5.89, SD=1.58) and third round

(M=5.97, SD=1.40) data. The land managers also agree that the 'people/organisations whose advice they follow most think that they should do this' influences their decisions about handling run-off in both first round (M=5.74, SD=1.84) and third round (M=5.86, SD=1.63) data collection. Land managers somewhat disagreed in both first round (M=3.31, SD=2.34) and third round (M=3.68, SD=2.46) data collection that land managers in the region would not be able to afford to use the systems to calculate fertiliser rates, indicating that the systems mentioned are affordable. The respondents somewhat disagree in both first round (M=3.10, SD=2.30) and third round (M=2.94, SD=2.12), that other land managers in the area would not have the technical knowledge to handle run-off, indicating that they would have the technical knowledge. Land managers also strongly disagreed that they were being forced to use the run-off handling methods, see Table 19. There were no significant difference in scores for each statement.

Table 19: Wet Tropics land manager attitudes and motivations associated with handling run-off

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
The farmers I respect most do this	192	5.89	1.58	69	5.97	1.40
The people/organisations whose advice I follow most think I should do this	189	5.74	1.84	69	5.86	1.63
Most farmers in this region would not be able to afford to use this system for handling run-off	192	3.31	2.34	69	3.68	2.46
Most farmers in this region would not have the technical knowledge to do this	192	3.10	2.30	69	2.94	2.12
I only do this because I am forced to. Who/what is forcing you?	184	1.98	2.06	69	1.80	1.68
*Note: 1=most important, 12=least important, *=significant at 5%*						

The second set of statements ask the land manager to read the statement and respond how using their method for handling run-off measured when compared to other ways of handling run-off.

While all statements have a high level of agreement (see Table 20) 'the best way to meet my own personal goals', 'the most effective way of controlling nutrient loss from my property', 'the best way to maintain good cash flow and 'the best way to reduce business risk' are the most significant motivators for using the method for handling run-off that the land manager is using. In both rounds of data collection land managers somewhat agreed that the way they handled run-off was the 'least time consuming'.

Table 20: Compared to other ways of handling run-off, what motivates Wet Tropics land managers to use the system that they use?

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
The best way to meet my own personal goals	190	6.33	1.04	69	6.07	1.23
The most effective way of controlling nutrient loss from my property	188	6.33	1.04	69	6.19	1.32
The best way to maintain good cash-flow	190	6.08	1.29	69	5.84	1.69
The best way to reduce business risk	191	6.04	1.28	69	5.86	1.46
The least time-consuming (or labour intensive)	191	5.67	1.67	69	5.46	1.80
*Note: 1=most important, 12=least important, *=significant at 5%*						

An independent t-test highlighted a significant difference for 'the least time consuming' score for first round (M=5.50, SD=1.56) and third round (M=4.96, SD=1.81; t(101)=2.22, p=.03, two tailed). The magnitude of difference in the means (mean difference =.30, 95% CI: .01 to .61) was small (eta squared =.01). The results indicate that while handling run-off is the least time consuming, it had increased in importance between first round and third round data collection, only 1% of the variance was explain by time between the data collection points. This may be due to land managers not capturing run-off from irrigation, which is not widely used in the Wet Tropics region. There was no significant difference between the other means across the two data collection periods.

Has handling run-off practices changed?

To establish whether there was a change in the way land managers handle run-off between first and third round data collection, a multiple response cross-tabulation was performed (see Table 21). The land manager unique identification number was used to identify growers in each round of data collection (1=Grower First Round and 3=Same Grower Third Round). There were 61 growers who responded to the statements in first round and 12 who responded in the third round of data collection.

While the response rate of those who completed the survey in both rounds is low, the data indicates that less land managers are using recycle pits in third round (33.3%) than in first round (65.6%) data collection. More land managers reported not capturing run-off in third round (50%) compared to first round (36.1%). More land managers reported having recycle pits with adequate pumping capacity to recycle the water in third round (16.7%) than in first round (1.6%) data collection. While the data in Table 21 indicates changes in the way that land managers are handling run-off, the results cannot determine if land managers are using best practice management techniques to handle run-off or some other method.

Table 21: Comparison between 'How first and third round Wet Tropics land managers handle run-off'

How do you handle run-off?		**Have you completed this survey before?**		
		Grower 1st Round	**Same Grower 3rd Round**	**Total**
I have recycle pits/Sediment traps	Count	40	4	44
	% within $Run-off	90.9%	9.1%	
	% within CompBefore	65.6%	33.3%	
	% of Total	54.8%	5.5%	60.3%
I do not capture run-off	Count	22	6	28
	% within $Run-off	78.6%	21.4%	
	% within CompBefore	36.1%	50.0%	
	% of Total	30.1%	8.2%	38.4%
I have recycle pits and have adequate pumping capacity to recycle the water	Count	1	2	3
	% within $Run-off	33.3%	66.7%	
	% within CompBefore	1.6%	16.7%	
	% of Total	1.4%	2.7%	4.1%
	Count	**61**	**12**	**73**
	% of Total	**83.6%**	**16.4%**	**100.0%**

Percentages and totals are based on responses.
a. Dichotomy group tabulated at value 1.

6.3.1.5 Other Innovative Run-off Practices

Land managers were asked if they used any other innovative practices to manage nitrogen and/or run-off. Sixty three percent selected yes that they thought they were using innovative practices in first round data collection and 33.9% selected yes in the third round. However, when matching responses to the ABCD Framework, the practices used meet conventional to best management practice expectations. A list of anecdotal comments from land managers describing the practices are included in Appendix 3.

Table 22: Other innovative practices - anecdotal comments from Wet Tropics land managers, coded (see Appendix 3 for examples)

Do you use any other innovative practices to manage nitrogen and/or run-off?		**1st Round**		**3rd Round**	
		n	**Percent**	**n**	**Percent**
Yes		147	63.6	40	33.9
No		84	36.4	28	41.2
Total		**231**	**100**	**68**	**100**
Coded Responses to Innovative Practices (see examples in Appendix 3)	**ABCD Framework**	**1st Round**		**3rd Round**	
		n	**Percent**	**n**	**Percent**
Fertiliser/Bio Fertiliser	C, B	75	50.3	29	52.7
Alternative Crops/Irrigation	C, B	13	8.7	11	20.0
Headlands/Drains/Recycle Pits/Laser Levelling	B	17	11.4	5	9.1
Green Trash Blanket/Composting	C, B	14	9.4	4	7.3
Stool Splitting Mixed Method	C	29	19.5	4	7.3
Best Management Practices	C, B	1	0.7	2	3.6
Total		**149**	**100**	**55**	**100**

6.3.1.6 Perceptions of Causes and Pressure on Water Quality

Land managers were asked to agree (7) or disagree (1) with a statement about how nutrient loss impacts water quality in local streams, rivers and waterways. They could also select that they did not know or were unsure how local streams, rivers and waterways were impacted (8) or neutral (4).

A means analysis shows that overall land managers held a neutral view, they neither agree nor disagree with the statement about the whether or not nutrient loss from their property has an impact on local streams, rivers and waterways.

Table 23: Means analysis of the statement about how nutrient loss impacts Wet Tropics water quality

	1st Round			**3rd Round**		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
Nutrient loss from my property has no impact on water quality in local streams, rivers & waterways	246	4.90	2.21	69	4.86	2.23
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

A frequency analysis indicates that land managers in both first round (41.9%) and third round (37.7%) data collection do not think that nutrient loss from their property has an impact on water quality in local streams, rivers and waterways. By contrast 30% in both rounds do think

that nutrient loss has an impact. While 15% in each round of data collection remained neutral, i.e. neither agreeing nor disagreeing, slightly more land managers in the third round did not know or were not sure if nutrient loss from their property has an impact on water quality in local streams, rivers and waterways.

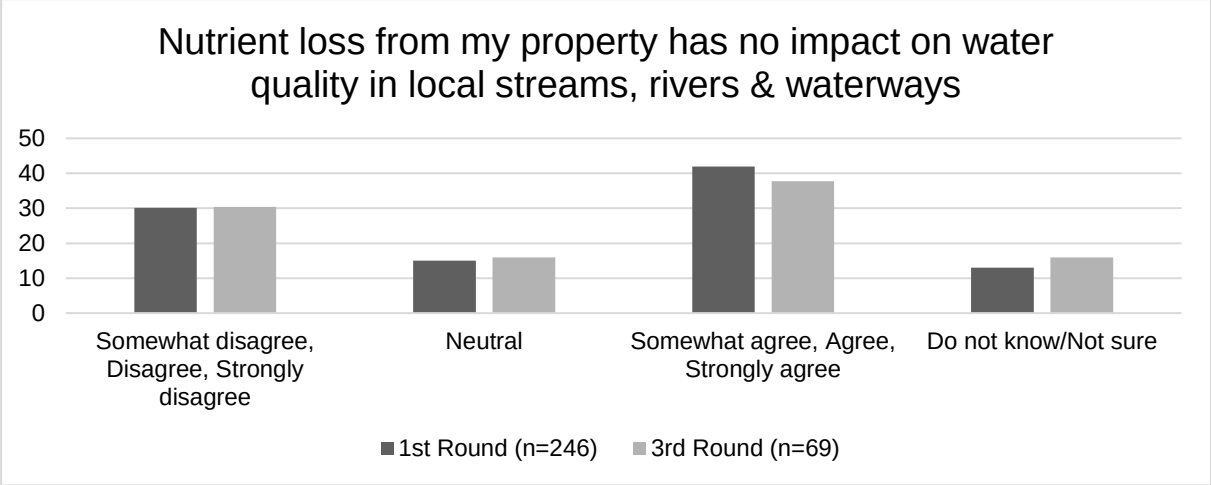

Figure 3: Responses from Wet Tropics land managers about nutrient loss from their property impacting local streams, rivers and waterways

When asked what Wet Tropics land managers thought was the top two causes of poor water quality in local streams, rivers and waterways, first round responders offered, other farming as the top most cause and urban development as the second top cause. In the third round of data collection, the top cause identified by land managers was weather including natural run-off from heavy rainfall and floods and the second top cause was farming. In particular, farming was identified as banana, grazing, fruit growing, hobby farmers, cane farming and excess nutrients, chemicals and pesticides that come from farming. In both rounds of data collection, a small percentage of land managers commented that there was no poor water quality, although the responses were less in the third round of data collection. Congruent with first round data reporting (Farr, Eagle, Hay, & Churchill, 2017c), the data indicates that land managers in the cane industry may be shifting the blame for the causes of poor water quality to other farmers (bananas, grazing and fruit growing), industry, government and individuals. Interestingly, very little blame is attributed to urban development, which is often cited by land managers as the main cause of poor water quality in the GBR Basin, see Appendix 6.

Table 24: Wet Tropics land managers - Top causes of poor water quality in local streams, rivers and water ways

	1st Round				3rd Round			
	Cause 1		Cause 2		Cause 1		Cause 2	
	n	Percent	n	Percent	n	Percent	n	Percent
Farming (Banana, Cane, Grazing and Fruit Growing)	42	19.3	32	23.7	14	13.6	13	20.3
Feral Animals (Pigs)	37	17.0	17	12.6	19	18.4	7	10.9
Weather/Natural Run-off/Floods/Rainfall	33	15.1	17	12.6	29	28.2	14	21.9
Other Industry or Government	21	9.6	2	1.5	0	0.0	2	3.1
Blockages in creeks, clearing creeks and drains	19	8.7	10	7.4	6	5.8	6	9.4
Erosion	18	8.3	4	3.0	13	12.6	6	9.4
Illegal dumping/Accidental Spills/Pollution	15	6.9	2	1.5	0	0.0	0	0.0
No poor water quality	11	5.0	3	2.2	4	3.9	1	1.6
Bare ground	9	4.1	8	5.9	0	0.0	0	0.0
Cultivation Practices	4	1.8	11	8.1	3	2.9	2	3.1
Urban Development	3	1.4	24	17.8	9	8.7	9	14.1
Run-off	3	1.4	2	1.5	3	2.9	2	3.1
Construction/Civil Works	2	0.9	2	1.5	0	0.0	0	0.0
Climate Change/Global Warming	1	0.5	0	0.0	1	1.0	1	1.6
Don't know	0	0.0	1	0.7	2	1.9	1	1.6
Total	**218**	**100**	**135**	**100**	**103**	**100**	**64**	**100**

Next land managers were asked to strongly agree (7) or strongly disagree (1) with a statement about the role that cane-growing plays in the declining health of the Great Barrier Reef (GBR). Land managers could also select that they did not know or were unsure (8) or neutral (4) about what role cane growing plays in the declining health of the GBR.

A means analysis indicates a neutral stance in the first round data and a somewhat agree stance in third round data (see Table 25) about cane growing playing no role in the declining health of the Great Barrier Reef.

Table 25: Means analysis of Wet Tropics land manager statement about the role cane growing plays in the declining health of the Great Barrier Reef

	1st Round			3rd Round		
	n	Mean	SD	n	Mean	SD
Cane-growing plays almost no role in the declining health of the Great Barrier Reef	243	4.89	1.89	69	5.33	1.98

A frequency analysis of the same data shows a strong agreeance in both rounds of data collection (see Figure 4), indicating that land managers in the Wet Tropics cane growing region do not think that cane growing contributes to the declining health of the GBR.

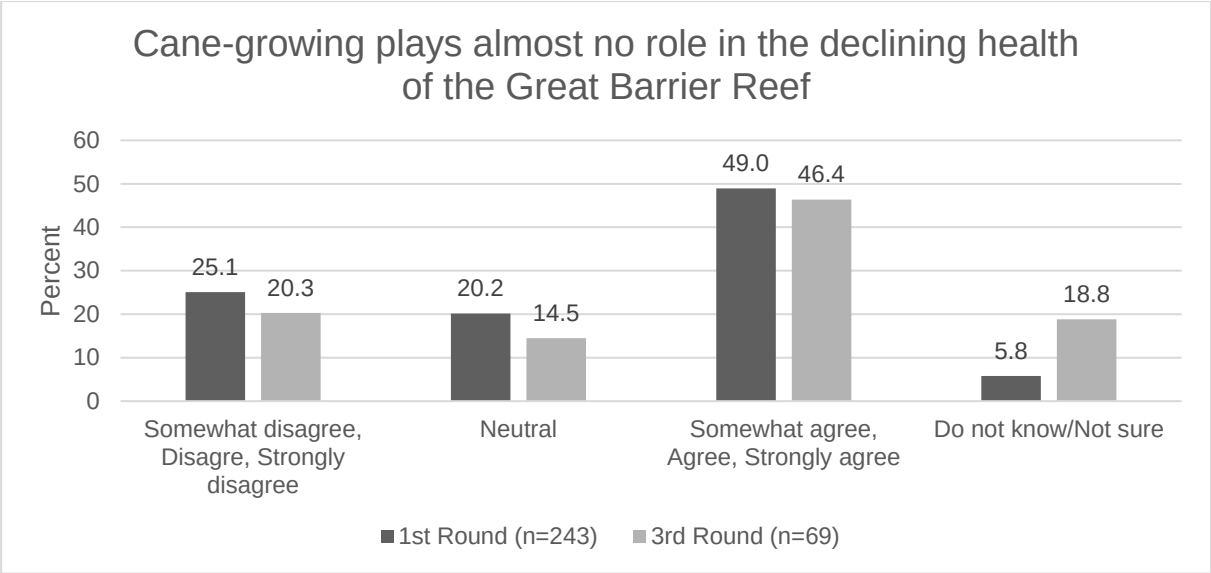

Figure 4: Responses from Wet Tropics land managers about the role cane growing plays in the declining health of the Great Barrier Reef

Participants were asked to write their comments about what they thought the two top pressures were on the GBR. In the first round data, land managers listed climate change (natural cycles) or global warming (rising sea temperatures) and weather (floods, natural run-off, heavy rainfall, cyclones, lack of rainfall and extreme weather events) as the top pressures on the Great Barrier Reef. This was followed by urban development, weather and climate change, which was listed as the second top pressure on the health of the GBR in the first round of data collection. In the third round, climate change and global warming were still listed as the top pressure along with tourism, fishing and shipping (in that order).

The second top pressure listed by land managers in the third round of data collection was weather, followed by urban development, then tourism, fishing and shipping (in that order). Only a small percentage of land managers acknowledged that farming (cane, banana, grazing, and fruit growing) added pressure to the health of the GBR. These results support earlier findings (Farr et al., 2017c, pp. 64-65) that land managers tend to shift the blame related to water quality and the health of the Great Barrier Reef to other organisations, industries and individuals rather than consider their own practices as adding pressure to the GBR.

Table 26: Wet Tropics land manager - two top pressures on the health of the Great Barrier Reef

	1st Round				3rd Round			
	Pressure 1		Pressure 2		Pressure 1		Pressure 2	
	n	Percent	n	Percent	n	Percent	n	Percent
Climate Change/Global Warming	72	32.4	25	12.8	38	36.9	6	6.5
Urban Development	43	19.4	40	20.5	9	8.7	18	19.4
Weather/Natural Run-off/Floods/Rainfall	38	17.1	36	18.5	15	14.6	22	23.7
Fishing/Shipping/Tourism	24	10.8	24	12.3	16	15.5	14	15.1
Acidification/CoT/Coral Bleaching	11	5.0	16	8.2	2	1.9	11	11.8
Farming (Banana, Cane, grazing and Fruit Growers)	10	4.5	12	6.2	1	1.0	3	3.2
Run-off	9	4.1	24	12.3	4	3.9	10	10.8
Erosion	3	1.4	2	1.0	0	0.0	0	0.0
Feral Animals (Pigs)	3	1.4	6	3.1	1	1.0	0	0.0
Other Industry or Government, Research	3	1.4	7	3.6	13	12.6	4	4.3
Cultivation Practices	2	0.9	0	0.0	0	0.0	0	0.0
Blockages in creeks, cleaning creeks and drains	1	0.5	0	0.0	1	1.0	1	1.1
No poor water quality	0	0.0	0	0.0	1	1.0	0	0.0
Illegal dumping/Accidental Spills/Pollution	0	0.0	1	0.5	2	1.9	4	4.3
Construction/Civil Works	0	0.0	1	0.5	0	0.0	0	0.0
Don't know	3	1.4	1	0.5	0	0.0	0	0.0
Total	**222**	**100**	**195**	**100**	**103**	**100**	**93**	**100**

6.3.1.7 Wet Tropics Cane Growers Results Summary

This section has reported on results from questions related to nutrient and run-off management practices in the wet tropics region of Queensland, Australia.

The results from the analysis confirm that land managers in the wet tropics goals for their property are to improve their land and remain productive and sustainable into the future. When making decisions to reach their goals, land managers are driven by maintaining family traditions and heritage and by maintaining good relations with other farmers in their local area. While maintaining physical and mental health, spending time with the family and keeping in contact with family and friends were important, they were not seen as influencers to decision making.

Financially, land managers are influenced by maximising profits and servicing debt and they are also influenced by having their efforts recognised by the wider community and sharing new ideas with others. Both having efforts recognised and sharing new ideas have increased in importance as influencers during the study. Likewise, minimising run-off and/or nutrient losses has increased in importance as an influencer over the duration of the study. When thinking about environmental influencers, safeguarding local waterways and the GBR were more important than safeguarding native plants and animals, when making decisions on what to do on the land manager's property.

The data shows that when calculating fertiliser rates, the main practice is to tailor fertiliser rates to different parts of the property. However, there has been a slight increase in participants that are using industry standards over the duration of the study. This change may be due to an increase in advisors calculating fertiliser rates for land managers in the final year of the study. Advisors were identified as industry extension officers, private agronomists and researchers. Land managers also rely on their own knowledge and that of best management practices as well as fertiliser companies and resellers when calculating fertiliser application rates.

More than 60% of land managers nominated fertiliser resellers as their advisors, highlighting fertiliser resellers as highly influential to land managers when making decisions about calculating fertiliser rates. Anecdotal comments from land managers (and extension officers) during the study period have confirmed this influence as a reason for not following best management practice in fertiliser application. Several land managers (and extension officers) have also stated that land managers will ignore best management practice if the reseller incentivises fertiliser purchases e.g. buy two tonnes of fertiliser and get one tonne free.

When making decisions about fertiliser rates land managers are influenced by farmers they respect and how they are calculating their fertiliser rates. The regions land managers survey results indicate that other land managers had the technical knowledge and that they would be able to afford to implement the systems used to calculate fertiliser rates. The way that land managers calculate fertiliser rates was identified as the best way to meet their own personal goal and that they selected the method they used because it was the least time consuming.

When comparing the same land managers who completed the survey in the first round and again in the third round, the data showed that there has been a change in the way land managers are calculating fertiliser application rates. More land managers are using industry standard rates for district yield potential, calculating rates for high yielding blocks, using advisors and using estimates from farm yield. While less land managers are using more fertiliser on low yielding blocks that on other blocks. While the results indicate changes in the way that land managers are calculating their fertiliser application rates, the results cannot determine if land managers are using best practice management techniques to calculate fertiliser rates or some other method. It should be noted that many of the repeat survey respondents are most likely still engaged and value best management processes that have supported them. By contrast, some of the growers who have not made changes may have decided not to participate in the survey, which may affect the results of the survey.

Land managers highlighted industry extension and private agronomists as advisors whose advice they follow most in both rounds of data collection. In first round the third most trusted advisor was selected as ‘other’ and included advisors as their own experience, fertiliser resellers, and best management practice, agronomists, financial constraints and agricultural productivity boards. In third round, the third highest ranked advisor was researchers followed by family who are also cane farmers. The least followed advice in first round was regional cane associations and in third round was people from government departments. The data indicates, while land managers followed advice from people from government departments more in first round data collection (individually ranked third), they were not following their advice in third round as evidenced by being ranked twelfth by land managers.

When handling run-off nearly one third of land managers are following conventional run-off management practices such as using recycle pits and sediment traps and one third are not capturing run-off. However, this may be a result of not using irrigation practices in the Wet Tropics region.

Land managers are influenced to make their decisions about handling run-off by farmers they respect, and by the people or organisations whose advice they follow most and think that they should do the practice. The survey results indicate that the respondent land managers think that other land managers have the technical knowledge to implement and that they would be able to afford to implement the systems used to handle run-off. The surveyed land managers identified that no one was forcing them to use the methods that they were using to handle run-off. The way that land managers calculate fertiliser rates was identified as the best way to meet their own personal goal, the most effective way of controlling nutrient loss from their property, the best way to maintain good cash flow and the best way to reduce business risk. However, the method being the least time consuming was highlighted as the main motivator for calculating run-off.

The majority of land manager respondents identified that they were using other innovative practices to manage nitrogen and/or run-off. When matching responses to the ABCD Framework, it was identified that the practices being used met conventional to best management practice expectations.

Overall the land managers surveyed neither agreed nor disagreed that nutrient losses from their property have an impact on local streams, rivers and waterways. On closer inspection the data shows that surveyed land managers think that nutrient loss from their property does not have an impact on water quality in local streams, rivers and waterways. However, less land managers felt this way at the end of the study. By contrast in both rounds of data collection, nearly one third of participants did think that nutrient loss has an impact on water quality. The remainder either did not know or remained neutral in their thoughts.

In the beginning of the survey period, land managers identified problems with water quality being caused by other farmers, by the end of the study, they identified the weather (high rainfall, natural run-off, floods, cyclones and extreme weather events) to be the top causes of poor water quality. By contrast climate change and global warming were the least causes of poor water quality in local streams, rivers and waterways.

Cane farmers in the Wet Tropics region indicated that cane growing does not contribute to the declining health of the Great Barrier Reef. They identified the top pressure in the beginning of the study to be climate change or global warming and urban development, in the final year of the study land managers identified the pressure on the health of the Great Barrier Reef also to be caused by climate change or global warming or other weather related events.

6.3.2 Burdekin Sugar Cane Nutrient and Run-off Management Practices, Results from Round 3 Land Managers Survey

The Burdekin region survey was delivered by telephone to land managers using James Cook University research staff. The data was directly entered into Qualtrics using the Survey

Software. Each telephone interview took approximately 40 minutes to complete. The data imported to SPSS for analysis. For cane farming a total of 76 surveys were collected in 2018. In 2016, 53 surveys were completed bringing the total number of surveys to 129. For grazing a total of 105 surveys were collected in 2018. In 2016, 80 surveys were completed bringing the total number of surveys to 185.

Data from the first round (2016) of the Burdekin survey was compared with the third round (2018) Burdekin survey results to determine if there were any changes to behaviour or attitude towards improving nutrient and run-off practices for improved water quality in the GBR Basin. Below are the results from questions related to nutrient and run-off management practices, results from structural equation modelling are presented in Section 6.3.4.

6.3.2.1 Factors that influence land manager decisions

To understand the factors that influence their decisions, land managers were asked to identify the two most important things that they hoped to achieve for their farm or property.

Land managers comments were coded into themes using first round and third round data. In the first round of the study, the main goal of land managers was to be productive and efficient and their second goal focussed on improving farming practices for both profit and the environment. In the third round of the study, land managers main goal had changed slightly to remaining viable, having financial security and reducing debt and their second goal was then focussed on improving productivity and farming practices. The responses indicate that improving their land so that it can remain productive and sustainable into the future is important to land managers, highlighting a motivation to participate in good farming practices.

Table 27: Burdekin sugar cane land manager's personal goals to achieve on farm/property

1st Round	3rd Round
Goal 1 – Productivity/Efficiency	**Goal 1 – Viability/Financial Security**
Production - produce the most you possibly can; most efficient production; better productivity, get more out of the land	To make a reasonable living and live comfortably; financially viable; retire in a good financial position; financial success
Goal 2 – Improving farming practices for profit and environment	**Goal 2 - Productivity/Efficiency**
Continually educate ourselves to be the best farmers we can be. Pass on this knowledge as we go to friends and family; to produce the best tonnes per sugar per HA while still providing environmental practices. it's a balance of both and neither one should compromise each other; diversification into value adding products; keep improving the property, more efficient, make profit	Continuing to improve crop yields; maintain yields and reduce my inputs; make it a mantel piece for productivity; efficient farming

6.3.2.2 Decision making drivers

The next question asked land managers how important they thought a set of 21 statements were when making decisions about what to do on their farm or property (See Table 28). The participants were asked to choose the importance of each statement on a scale of 1-extremely unimportant to 8 where 7 was equal to extremely important (essential) and 8 was equal to 'I don't know', the number 4 was listed as neutral. A means analysis was applied to compare

first and third round land manager responses. Followed by an independent samples t-test to establish any significant difference in the responses.

Family, friends and other land manager influences

The first set of statements consider family, friends, health and other land manager influences when making decisions. All of the statements were more important in the third round of data collection than they were in the first round, except for 'maintaining traditions and heritage'. While 'maintaining physical and mental health of family' was selected as important to extremely important, by contrast, land managers selected 'maintaining traditions and heritage' as being less important, rating the statement between neutral and important when making decisions on their farm or property. An independent t-test showed that none of the statements were statistically different between data collection points.

Financial influencers

Similarly, all of the statements that considered financial influences (keeping farming cost low, maximising profits, minimising risk, keeping a steady cash flow and servicing debt) were indicated as important. However, in this case land managers rated them as less important to consider when making decisions about what to do on the farm in the third round of data collection compared to the first round data collection. Of least importance in third round data when making decisions was 'servicing debt' indicating that other influencers were more important. There was no statistical difference for decision influencers between data collection points.

Land management influencers

The next set of statements consider land management influences when making decisions. There is a statistical difference between first and third round data collection in one land management statement. Land managers felt that 'learning about and testing new ways of doing things on their farm or property' was more important in first round data (M=6.17; SD=1.03) than in the third round (M=5.69, SD=1.33; t(91)=1.91, p=.05, two tailed) when making decisions about what to do on their property. While the other statements were identified as important, there was no statistical difference between statements over the data collection points. 'Being able to make their own decisions about their farm/property' was the most important in the first and third round of data collection. 'Having efforts recognised by the wider community' was the least important consideration in both first and third round data collection for land managers when making decisions about what to do on the Burdekin cane farmers properties.

Farming practices

When considering how farming practices influence decisions, there was a statistical difference between first round (M=6.59; SD=0.86) and third round (M=6.18, SD=1.05; t(91)=2.07, p=.04, two tailed) data collection for 'leaving the land/farm in better condition than it was when the land manager got there'. While rated as important, the scores show that leaving the farm in better condition is slightly less important in third round data collection than it was in first round data collection. While maintaining or improving water supplies and storage and minimising sediment run-off or nutrient losses were rated as important, there is no statistical difference between land manager responses in the first round to the third round, indicating that these factors are considered important to decisions about what to do on the land managers farm or property.

Safeguarding local waterways, native plants and animals and the Great Barrier Reef

The final set of statements indicate that safeguarding local waterways, the Great Barrier Reef (GBR) and native plants and animals are important to land managers. There is a statistical difference between first round and third round data for all three statements about safeguarding local waterways (first round M=6.36; SD=1.03 and third round (M=5.78, SD=1.29; t(91)=2.11, p=.04, two tailed), native plants and animals (first round M=5.95; SD=1.38 and third round (M=5.14, SD=1.52; t(91)=2.68, p=.00, two tailed) and the Great Barrier Reef (first round M=6.40; SD=1.15 and third round (M=5.84, SD=1.27; t(91)=2.42, p=.01, two tailed). However, while overall the level of importance that influences decisions about what to do on the land managers farm or property has decreased between first and third year data collection, the statements about safeguarding native plants and animals and helping to safeguard the GBR are more significant than safeguarding local water ways.

Table 28: Burdekin sugar cane land manager responses decision making drivers

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
Maintaining physical and mental health of family	42	6.19	1.45	51	6.31	1.22
Spending face-to-face time with family and friends	42	5.79	1.57	51	6.06	1.03
Maintaining good relations with other farmers/graziers in the local area	42	5.43	1.50	51	5.43	1.25
Keeping in contact with family and friends in other ways (e.g. via phone, through social media)	42	5.31	1.55	51	5.45	1.53
Maintaining family traditions and heritage	42	5.05	1.94	51	4.78	1.87
Keeping farm costs low	42	6.43	1.13	51	6.31	1.22
Maximising farm profits (income minus costs)	42	6.43	1.17	51	6.31	1.05
Minimising risk (of very high costs or very low income)	42	6.40	1.01	51	6.18	1.14
Keeping a stable (steady) cash-flow	42	6.29	1.33	51	6.20	1.30
Servicing debt	42	6.14	1.37	51	5.82	1.35
Being able to make your own decisions about your farm/property	42	6.45	1.27	51	6.35	1.02
Learning about and testing new ways of doing things on your farm/property*	42	6.17	1.03	51	5.69	1.33
Sharing new ideas with others	42	5.64	1.41	51	5.10	1.60
Having time to pursue hobbies	42	5.26	1.52	51	4.78	1.69
Having efforts recognised by the wider community	42	4.57	1.82	51	4.08	1.80
Leaving the land/farm in better condition than it was when you first started managing it*	42	6.60	0.86	51	6.18	1.05
Maintaining/improving water supplies and storages	42	6.50	0.97	51	6.16	1.07
Minimising sediment run-off and/or nutrient losses	42	6.40	1.27	51	6.14	1.39
Helping to safeguard the Great Barrier Reef*	42	6.40	1.15	51	5.84	1.27
Helping to safeguard local waterways*	42	6.36	1.03	51	5.78	1.29
Helping to safeguard native plants and animals*	42	5.95	1.38	51	5.14	1.52
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

6.3.2.3 Irrigation Management Practices

Land managers were asked to answer a series of questions about their irrigation management practices. The questions were asked to help the researchers to know the reasons why Burdekin Cane Growers are doing specific agricultural practices and what motivates them to make those decisions, as well as whose advice the land managers are following. The responses from the first round of data were compared to responses from the third round of data to identify any changes in irrigation management practices.

Irrigation practices

When asked if they use irrigation practices, 92.1% of land managers in the first round and 97.7% in the third round of data collection responded 'Yes'. The amount of water used varied from 2 mega litres (ML) to 20ML per hectare per year. Land managers added that it depended on the soil type and on whether it was a dry or a wet year. In the first round of data collection 91.4% of land managers thought that between zero and 25% of irrigation water ran off the block, the number was slightly less in the third round (88.1%). More land managers selected that 25-50% of irrigation water runs off their block in third round (11.9%) data collection, compared to the first round (8.6%).

Type of irrigation tools used

Land managers were asked what type of irrigation tools that they used. More land managers are using soil moisture probes in the third round (30.4) of the study than in the first round (24.2%). By contrast less selected mini pans (an in furrow irrigation system that relies on evaporation to refill) as their irrigation tool of choice in the third round. Of the land managers that selected other, more than 50% in each round of data collection wrote that they used experience as their main tool for managing irrigation. In the third round 40% of those that selected other are using g-dots (a new system that measures a kPa range to indicate when irrigation is required, which helps to reduce both electricity consumption and run-off) as their irrigation tool. When asked if they planned to use the same tools next year 93.9% in the first round and 81.3% in the third round of data collection agreed that they would use the same irrigation tools. Of those that were not going to use the same tools, they commented that they would use electronic moisture testing, an automated system or a soil moisture meter.

Table 29: Type of irrigation tools used by Burdekin sugar cane land managers

	1st Round		3rd Round	
	n	**Percent**	**n**	**Percent**
Soil moisture probes such as tensiometers and capacitance probes (to identify water use and predict next irrigation)	16	24.2	18	30.4
Mini pans (in furrow-irrigated system based on evaporation)	15	22.7	5	8.9
Calculation of daily crop water use, using crop factors, class A pan, or crop model (e.g. WaterSense).	10	15.2	4	5.4
None	5	7.6	11	19.6
Other (please tell us which ones)*	20	30.3	20	35.7
	66	**100**	**56**	**100**
***Other**				
Experience (gut feeling, experienced eye, rule of thumb, years of observation, scheduling)	11	55.0	10	50.0
Enviropans, trickle irrigation, run pumps, recycle pit	4	20.0	0	0.0
G-dots (a new type of tensiometer)	2	10.0	8	40.0
Leaf Stress, plant growth rate	2	10.0	0	0.0
Evaporation bucket calibrated to growth of cane	1	5.0	0	0.0
	20	**100**	**18**	**100**

Advice land managers follow when scheduling irrigation?

Land managers were asked to rank from 1= most important to 12=least important whose advice they follow most when scheduling irrigation. However, due to third round data being collected via telephone interviews, the participants found it difficult to remember and rank 12 variables (see ** in Table 30). Therefore, participants were given the option to rank only the top 5 advisors they follow when scheduling irrigation. A cross tabulation between 'advice land managers follow when scheduling irrigation' and 'round of data collection' compared the top five responses from the third round of data collection (see Table 30).

The first round results are not accurate due to a skip logic error in the first round data collection; therefore the results are not reported here and no comparison can be made between first round and third round.

In the third round data collection, the advisors ranked private agronomists as the top advisor, followed by industry extension, family who are also cane farmers, others, and people from NQ Dry Tropics. Other advisors were listed as using land managers own experience, farmers from different industries, and extension officers from farm assist and government (see Table 30).

Table 30: Advice Burdekin sugar cane land managers follow when considering irrigation, ranked 1 most important to 12 least important – 3rd Round data collection – top 5

Advisor	3rd Round												
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Private Agronomists	10	1	3	2	0	0	0	0	0	0	0	0	16
Industry extension advisors (e.g. from SRA [BSES], Production Boards, Productivity Services group)	7	9	1	0	2	0	0	0	0	0	0	0	19
Family who are also cane farmers	4	1	3	2	0	1	0	0	0	0	0	1	12
Other. Who?*	4	1	0	0	1	1	0	0	1	1	0	0	9
People from NQ Dry Tropics	1	2	2	1	0	0	0	2	0	0	0	0	8

**Other. Who? (Number of responses): their own experience (4), farmers in different industries where irrigation is a lot more critical, such as small crops (1); extension officers from farmassist (1); Government Departments: DAFF/DERM (2), TNR (1)*

*****List of 12 advisors that land managers could choose from:** Family who are also cane farmers; Other cane farmers; Private Agronomists; Researchers; Cane Growers (the organisation); Regional cane association (e.g. from Kalamia, Invicta, Inkerman, Tully Sugar); People from NQ Dry Tropics/TERRAIN; Other. Who?; Landcare; Industry extension advisors (e.g. from SRA [BSES], Production Boards, Productivity Services group); Other extension officers. From where?; People from government departments. Which departments?*

While there was less focus on resellers and fertiliser companies as advisors in the Burdekin region as compared to the Wet Tropics region, it is important to note the influence that networks have on land manager decisions. These networks may be identified as either positive or negative and may become enablers or barriers to practice change. The findings support previous recommendations for a land manager network analysis to ensure that information gatekeepers and opinion leaders influence future water quality communication strategies (see Hay & Eagle, 2018).

Attitudes and motivations associated with current tools for scheduling irrigation

The next question asked participants how important they thought a set of listed statements were to land managers when thinking about their current tools for scheduling irrigation. The participants were asked to choose the importance of each statement on a scale of 1-strongly disagree to 7 strongly agree, with 4 being neutral. There was also an option to select 8, I don't know or not sure.

The first set of statements considers land manager influencers when thinking about their current tools for scheduling irrigation. The results indicate that land managers decisions about scheduling irrigation are somewhat influenced by 'the farmers I respect most do this' in both first round (M=5.83; SD=1.33) and third round (M=5.39; SD=1.81) data. Land managers selected neutral to somewhat disagree, about whether or not 'most farmers in the region would have the technical knowledge to schedule irrigation'. They also somewhat disagreed that most farmers would not be able to afford to use the system that they did for scheduling irrigation. There was a significant change in the choice 'I only do this because I am forced to' (by BMP accreditation, lack of money, state government or reducing labour, energy and water costs) in third round (M=2.00; SD=1.61) compared to first round (M=3.83; SD=2.64). The results

indicate that land managers disagree that they are being forced to make decisions about their current irrigation scheduling practices.

Table 31: Burdekin sugar cane land manager attitudes and motivations associated with scheduling irrigation

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
The farmers I respect most do this*	6	5.83	1.33	28	5.39	1.81
Most farmers in this region would not have the technical knowledge to do this	6	4.00	2.61	28	3.64	2.08
Most farmers in this region would not be able to afford to use this system for scheduling irrigation	6	4.83	3.19	28	3.64	2.13
I only do this because I am forced to. Who/what is forcing you?*	6	3.83	2.64	28	2.00	1.61
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

An independent t-test highlighted a significant difference for 'the farmers I respect most do this' scores for first round (M=5.83, SD=1.33) and third round (M=5.39, SD=1.81; t(32)=0.56, p=.05, two tailed). The magnitude of difference in the means (mean difference =.44, 95% CI: -1.15 to 2.04) was small (eta squared =.01). The results indicate that while the farmers that land managers respected most when scheduling irrigation increased in importance between first round and third round data collection, only 1% of the variance was explain by time between the data collection points.

The effect was opposite for the 'I only do this because I am forced to' factor. An independent t-test highlighted a significant difference for 'I only do this because I am forced to' scores for first round (M=3.83, SD=2.64) and third round (M=2.00, SD=1.61; t(32)=2.25, p=.03, two tailed). The magnitude of difference in the means (mean difference =1.83, 95% CI: 0.17 to 3.49) was large (eta squared =.14). The results indicate that land managers are feeling less forced to schedule their irrigation practices in the third round of the study compared to the first year of the study and that 14% of the variance can be explain by time between the data collection points. This may be influenced by new and affordable technologies that are available to indicate when irrigation is required e.g. G-Dots. There was no significant difference between the other means across the two data collection periods.

Land managers were next asked 'compared to other ways of scheduling irrigation, what motivates to you use the system that you use?' While all statements have high agreement (see Table 32) 'the most effective way of controlling nutrient loss from my property' (M=6.17, SD=1.47) is the most significant motivator for using the scheduling tools that the land manager is using.

Table 32: Compared to other ways of scheduling irrigation, what motivates Burdekin sugar cane land managers to use the system that you use?

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
The most effective way of controlling nutrient loss from my property*	6	6.17	1.47	28	4.75	1.51
The best way to maintain good cash-flow	6	6.17	1.33	28	5.29	1.05
The best way to reduce business risk	6	6.17	1.33	28	5.29	1.21
The best way to meet my own personal goals	6	6.00	1.41	28	5.46	0.88
The least time-consuming (or labour intensive)	6	5.17	2.23	28	5.29	1.49
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

An independent t-test highlighted a significant difference for 'the most effective way of controlling nutrient loss from my property' scores for first round (M=6.17, SD=1.47) and third round (M=4.75, SD=1.51; t(32)=2.09, p=.04, two tailed). The magnitude of difference in the means (mean difference =1.42, 95% CI: .04 to 2.79) was large (eta squared =.12). The results indicate that land managers in the third round of the study compared to the first year of the study, remain neutral or slightly disagree that the scheduling tools that they are using are the most effective way of controlling nutrient loss from their property and that 12% of the variance can be explain by time between the data collection points. The results may indicate a loss of confidence in the current tools used for scheduling irrigation or an uncertainty in the new tools being used, further investigation is required (see Table 32). There was no significant difference between the other means across the two data collection periods.

Have irrigation management practices changed?

To establish whether there was a change in the tools that land managers use to manage irrigation between first and third round data collection, a multiple response cross-tabulation was performed (see Table 33). The land manager unique identification number was used to identify growers in each round of data collection (1=Grower First Round and 3=Same Grower Third Round). There were 29 growers who responded to the statements in first round and 32 who responded in the third round of data collection.

The data indicates that less land manages have reported using mini pans in the third round to manage irrigation compared to the first round of data collection. More land managers are soil moisture probes as their tool to manage irrigation. By contrast, there has been a large reduction in those land managers who responded that are calculating daily crop water usage to manage irrigation from 20% in first round to 7% in third round. However, there has been a slight increase in land manager who are using 'other' tools, see Table 33 for examples. While the data in Table 33 indicates changes in the tools that land managers are using to manage irrigation, the results cannot determine if land managers are using best practice management techniques for irrigation management or some other method.

Table 33: Comparison between 'How first and third round Burdekin sugar cane land managers manage irrigation'

Have the tools that land managers use to manage irrigation changed?		Have you completed this survey before?		
		Grower 1st Round	Same Grower 3rd Round	Total
Mini pans	Count	17	3	20
	% within $IrrigTools	85.0%	15.0%	
	% within CompBefore	28.3%	21.4%	
	% of Total	23.0%	4.1%	27.0%
Soil moisture probes such as tensiometers and capacitance probes	Count	24	7	31
	% within $IrrigTools	77.4%	22.6%	
	% within CompBefore	40.0%	50.0%	
	% of Total	32.4%	9.5%	41.9%
Calculation of daily crop water use, using crop factors, class A pan, or crop model (e. g. WaterSense).	Count	12	1	13
	% within $IrrigTools	92.3%	7.7%	
	% within CompBefore	20.0%	7.1%	
	% of Total	16.2%	1.4%	17.6%
Other (includes: experience, enviropans, trickle irrigation, pumps, G-dots, leaf stress, evaporation bucket, automated irrigation)	Count	29	8	37
	% within $IrrigTools	78.4%	21.6%	
	% within CompBefore	48.3%	57.1%	
	% of Total	39.2%	10.8%	50.0%
Total	Count	60	14	74
	% of Total	81.1%	18.9%	100.0%

Percentages and totals are based on responses.
a. Dichotomy group tabulated at value 1.

6.3.2.4 Nutrient Management Practices

Land managers were asked to answer a series of questions about their nutrient management practices. The responses from the first round of data were compared to responses from the third round of data to identify any changes in nutrient management practices.

Calculating fertiliser application rates

When asked how land managers calculate their fertiliser application rates, the 32.8% of land managers in first round data collection and 29.4% in third round selected that they tailor their fertiliser rates to different parts of the property. Twenty percent in both first and third round data collection selected that their advisor calculates their fertiliser application rate for them. More land managers in third round than in first round chose 'Other' as their chosen method to calculate fertiliser application rates. Less land managers were using industry standards in the third round of the study than in the first round. Other methods for calculating fertiliser application rates include decisions based on soil tests, best management practice, depends on other factors, use the same for everything and advice from industry representatives or agronomists (see Table 34).

Table 34: Burdekin sugar cane land manager responses to the question 'How do you calculate fertiliser application rates?"

	1st Round		3rd Round	
	n	**Percent**	**n**	**Percent**
I tailor my fertiliser rates to different parts of the property	19	32.8	20	29.4
My advisor does this for me (farm assist, biological consultant)	12	20.7	14	20.6
Other. Please tell us what you do*	9	15.5	17	25.0
I use industry standard rates for district yield potential, and use that amount on all parts of my farm	8	13.8	8	11.8
I estimate amounts from my farm yield and use that amount on all parts of my farm	4	6.9	4	5.9
I use more fertiliser on high – performing (high yielding) blocks	3	5.2	2	2.9
I use more fertiliser on under-performing (low yield) blocks than on other blocks	3	5.2	3	4.4
Total	**58**	**100**	**68**	**100**
Other. Please tell us what you do*				
Decision based on soil tests	4	50.0	7	41.2
Best Management Practice (6 easy steps)	2	25.0	4	23.5
Depends on cash flow, ground water, experience, budget	1	12.5	3	17.6
I put the same amount on everything	1	12.5	0	0.0
Advice from agronomist, industry representative	0	0.0	3	17.6
Total	**8**	**100**	**17**	**100**

Advice land managers follow most when calculating fertiliser application rates

Land managers were asked to rank from 1= most important to 12=least important whose advice they follow most when calculating fertiliser application rates. A cross tabulation between 'advice land managers follow when calculating fertiliser rates' and 'round of data collection' compared responses from the first and third rounds of data collection (see Table 35 and Table 36).

In the first round of data collection land managers sought advice from private agronomists, industry extension and others for example their own experience, fertiliser companies and resellers, and through trial results. Other extension included Farm Assist and SRA and government agencies included DERM and EHP.

Table 35: Advice sugar cane land managers from the Burdekin follow when calculating fertiliser rates, ranked 1 most important to 12 least important – 1st Round data collection

Advisor	1st Round												
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Private Agronomists	17	5	4	3	0	0	0	0	0	0	0	0	**29**
Industry extension advisors (e.g. from SRA [BSES], Production Boards, Productivity Services group)	8	9	2	1	0	1	0	0	1	0	0	0	**22**
Other. Who?*	4	2	0	1	0	0	0	2	1	0	1	0	**11**
Researchers	4	1	3	2	1	4	0	1	0	0	0	0	**16**
Family who are also cane farmers	2	4	1	4	3	0	1	0	0	0	2	0	**17**
Other extension officers. From where?**	2	1	1	1	0	0	2	0	0	1	0	0	**8**
People from NQ Dry Tropics/TERRAIN	1	1	2	3	0	0	3	2	1	0	0	0	**13**
Landcare	0	0	1	1	1	0	0	1	2	3	0	1	**10**
Regional cane association (e.g. from Kalamia, Invicta, Inkerman, Tully Sugar)	0	1	0	0	1	2	1	2	3	1	1	0	**12**
Other cane farmers	0	1	5	1	3	3	0	0	0	1	0	0	**14**
Cane Growers (the organisation)	0	0	1	0	2	1	3	1	2	1	0	0	**11**
People from government departments. Which departments?***	0	0	1	0	0	0	1	1	0	1	2	2	**8**

**Other. Who? (Number of responses): their own experience (1), fertiliser companies and resellers (1), from local agronomists (3) and through trial results (1)*
***Other Extension, from where: Farm Assist (2), SRA (1).*
**** Government Departments: DERM (1), EHP (1)*

In the third round of data collection private agronomists were still the first call for advice, followed by industry extension and others including their own experience, fertiliser companies and resellers, best management practice and local agronomists. One land manager indicated that they had "been doing it so long that they did not need advice". Other extension was from Farm Assist and government agencies included DAF in the third round of data collection.

Table 36: Advice sugar cane land managers from the Burdekin follow when calculating fertiliser rates, ranked 1 most important to 12 least important – 3rd Round data collection

Advisor	3rd Round												
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Private Agronomists	14	5	1	1	2	0	0	1	0	0	1	0	**25**
Industry extension advisors (e.g. from SRA [BSES], Production Boards, Productivity Services group)	10	13	2	1	0	0	1	2	0	0	0	0	**29**
Other. Who?*	10	1	0	0	1	0	0	0	0	1	0	2	**15**
Other extension officers. From where?**	3	2	1	1	1	0	0	0	0	3	2	0	**13**
Researchers	2	1	2	1	0	2	0	1	3	1	0	0	**13**
Regional cane association (e.g. from Kalamia, Invicta, Inkerman, Tully Sugar)	1	0	1	0	2	0	3	0	1	1	0	0	**9**
Landcare	1	1	0	0	0	0	1	2	2	1	0	1	**9**
Family who are also cane farmers	0	1	8	3	2	2	0	0	0	0	0	1	**17**
People from NQ Dry Tropics/TERRAIN	0	2	0	1	1	1	1	2	2	0	0	0	**10**
People from government departments. Which departments?***	0	0	1	1	0	1	1	0	0	0	2	3	**9**
Cane Growers (the organisation)	0	2	0	2	0	1	1	1	0	1	2	0	**10**
Other cane farmers	0	4	9	3	1	2	1	0	0	0	1	0	**21**

**Other. Who? (Number of responses): their own experience (6), fertiliser companies and resellers (1), best management practice (1), from local agronomists (2) and no advice needed (1)*
***Other Extension, from where: Farm Assist (1).*
**** Government Departments: DAF (1)*

Attitudes and motivations associated with calculating fertiliser application rates

The next question asked participants how important they thought a set of listed statements were to land managers when making decisions about calculating fertiliser rates. The participants were asked to choose the importance of each statement on a scale of 1-strongly disagree to 7 strongly agree, with 4 being neutral.

The first set of statements considered influencers when making decisions about calculating fertiliser rates. The data indicates that land managers decisions are somewhat influenced by 'farmers they respect' with regard to fertiliser rate calculations in both first (M=5.16, SD=2.03) and third round (M=5.02, SD=1.79) data. Similarly, land managers are somewhat influenced by 'the people or organisations whose advice they follow most and think that they should do this' in first round (M=5.11; SD=1.93) and third round (M=5.09; SD=1.64). Land managers somewhat disagreed with the last three statements indicating that other land managers would able to afford to use the same systems to calculate fertiliser rates, they would have the technical skills and that they are not being forced to calculate fertilise applications rates by anyone. There were no significant difference in scores for each of the statements.

Table 37: Burdekin sugar cane land manager attitudes and motivations associated with calculating fertiliser application rates

	1st Round			3rd Round		
	n	Mean	SD	n	Mean	SD
The farmers I respect most do this	38	5.16	2.03	43	5.02	1.79
The people/organisations whose advice I follow most think I should do this	38	5.11	1.93	43	5.09	1.64
Most farmers in this region would not be able to afford to use this system for scheduling irrigation	38	3.82	2.13	43	3.26	2.09
Most farmers in this region would not have the technical knowledge to do this	38	3.74	2.16	43	3.65	2.22
I only do this because I am forced to. Who/what is forcing you?	38	3.26	2.08	43	2.47	2.15
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

The second set of statements ask the land manager to read the statement and respond how using their method for calculating fertiliser rates measures when compared to other ways of calculating fertiliser rates.

The data indicates that there is less agreement with the statements in the third round of data collection than in the first round (see Table 38). The current system the land manager uses being 'the most effective way of controlling nutrient loss from my property' is highlighted as significant by an independent t-test for first round (M=6.05; SD=.98) and third round (M=5.35; SD=1.62; t(79)=2.33, p=.02, two tailed) scores. The magnitude of difference in the means (mean difference =.70, 95% CI: .11 to 1.29) was moderate (eta squared =.07) indicating that 'the most effective way of controlling nutrient loss from their property' had increased in importance between first round and third round data collection, and that 6% of the variance was explain by time between the data collection points.

Table 38: Compared to other ways of calculating fertiliser rates, what motivates Burdekin sugar cane land managers to use the system that they use?

	1st Round			3rd Round		
	n	Mean	SD	n	Mean	SD
The most effective way of controlling nutrient loss from my property*	38	6.05	0.98	43	5.35	1.62
The best way to maintain good cash-flow	38	6.05	0.96	43	5.65	1.48
The best way to meet my own personal goals	38	5.82	1.23	43	5.70	1.41
The best way to reduce business risk	38	5.79	1.19	43	5.95	0.95
The least time-consuming (or labour intensive)	38	4.29	1.96	43	4.72	1.86
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

Has calculating fertiliser application rates changed?

To establish whether there was a change in the way land managers calculate fertiliser application rates between first and third round data collection, a multiple response cross-tabulation was performed (see Table 39). The land manager unique identification number was used to identify growers in each round of data collection (1=Grower First Round and 3=Same Grower Third Round). There were 55 growers who responded to the statements in first round and 13 who responded in the third round of data collection.

Results in Table 39 indicate that there has been a change in the way land managers calculate fertiliser application rates. While, none of the land managers who responded in the first round to the statement 'I use more fertiliser of high performing blocks' responded in the third round, more third round (15.4%) land managers are estimating amounts of fertiliser from their farm yield and then using that on all parts of their farm compared to first round land managers (9.1%). About the same number of land managers are using their advisor to calculate their fertiliser application rate in both first (38.2%) and third (38.5%) rounds of data collection. Similarly, slightly more land managers in first round (65.4%) compared to third round (61.5%) are tailoring their fertiliser rates to different parts of their property. Of concern is that 10% less land managers are using industry standard rates for district yield potential in third (15.4%) round compared to first (25.5%) round data collection?

Table 39: Burdekin sugar cane land manager comparison between 'How first and third round land managers calculate fertiliser application rates'

How do you calculate fertiliser application rates?		Have you completed this survey before?		
		Grower 1st Round	Same Grower 3rd Round	Total
I use more fertiliser on high – performing (high yielding) blocks	Count	5	0	5
	% within $FAPP	100.0%	0.0%	
	% within CompBefore	9.1%	0.0%	
	% of Total	7.4%	0.0%	7.4%
I estimate amounts from my farm yield and use that amount on all parts of my farm	Count	5	2	7
	% within $FAPP	71.4%	28.6%	
	% within CompBefore	9.1%	15.4%	
	% of Total	7.4%	2.9%	10.3%
My advisor does this for me	Count	21	5	26
	% within $FAPP	80.8%	19.2%	
	% within CompBefore	38.2%	38.5%	
	% of Total	30.9%	7.4%	38.2%
I use more fertiliser on under-performing (low yield) blocks than on other blocks	Count	3	0	3
	% within $FAPP	100.0%	0.0%	
	% within CompBefore	5.5%	0.0%	
	% of Total	4.4%	0.0%	4.4%
I tailor my fertiliser rates to different parts of the property	Count	31	8	39
	% within $FAPP	79.5%	20.5%	
	% within CompBefore	56.4%	61.5%	
	% of Total	45.6%	11.8%	57.4%
I use industry standard rates for district yield potential, and use that amount on all parts of my farm	Count	14	2	16
	% within $FAPP	87.5%	12.5%	
	% within CompBefore	25.5%	15.4%	
	% of Total	20.6%	2.9%	23.5%
Total	**Count**	**55**	**13**	**68**
	% of Total	**80.9%**	**19.1%**	**100%**

Percentages and totals are based on responses.
a. Dichotomy group tabulated at value 1.

While the data in Table 39 indicates changes in the way that land managers are calculating their fertiliser application rates, the results cannot determine if land managers are using best practice management techniques to calculate fertiliser rates or some other method. In addition, the sample is very small and therefore not representative of the entire Burdekin region.

6.3.2.5 Run-off Management Practices

Land managers were asked to answer a series of questions about their run-off management practices. The responses from the first round of data were compared to responses from the third round of data to identify any changes in run-off management practices.

Handling run-off

A multiple response analysis indicates that in first round one third (33.9%) of land managers were following conventional run-off management practices such as using recycle pits and sediment traps and 42% were following the same practices in third round. Another 30.5% were using recycling pits with adequate pumping capacity to recycle the water in the first round of data collection. This had decreased to 19.2% in the third round. Fifteen percent of land managers were not capturing run-off in third round, which is indicative of the Burdekin region that has less rainfall than the Wet Tropics region. Other practices in first round (30.5%), see Table 40, were either meeting minimum expectations or were current practices as promoted by the industry (ABCD Framework, Drewry et al., 2008; Trendell, 2013). By contrast this has also decreased in third round data collection to 23.1%.

Table 40: Burdekin sugar cane land manager responses to the question 'how do you handle run-off from rainfall or irrigation?'

	ABCD Framework	**1st Round**		**3rd Round**	
		n	Percent	n	Percent
I have recycle pits	C	20	33.9	22	42.3
I have recycle pits and have adequate pumping capacity to recycle the water	B	18	30.5	10	19.2
I do not capture run-off	D	3	5.1	8	15.4
Other. Please tell us what you do	C-B	18	30.5	12	23.1
Total		59	100	52	100
	ABCD Framework	**1st Round**		**3rd Round**	
Other*		**n**	**Percent**	**n**	**Percent**
Recycle pit/Sediment trap	C	3	18.8	4	33.3
Grass and Drains	C-B	3	18.8	1	8.3
Buffer Zones (end banks)/Riparian Boundary/Revegetation	C-B	3	18.8	4	33.3
Contouring	C-B	3	18.8	1	8.3
Laser levelled, silt trap, grass	C-B	1	6.3	0	0.0
Natural drainage filter	C-B	3	18.8	2	16.7
Total		16	100	12	100

Advice land managers follow most when handling run-off

Land managers were asked to rank from 1= most important to 12=least important whose advice they follow most when handling run-off. A cross tabulation between 'advice land managers follow when handling run-off' and 'round of data collection' compared responses from the first and third rounds of data collection (see Table 41 and Table 42).

Land managers in the first round sought advice from private agronomists, NRMs and industry extension when handling run-off. In the first round of data collection the advice followed least comes from people from government departments. While the question asked which departments, none were listed by land managers.

Table 41: Advice Burdekin sugar cane land managers follow when handling run-off, ranked 1 most important to 12 least important – 1st Round Data Collection

Advisor	**1st Round**												
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Private Agronomists	10	6	1	1	1	1	1	1	0	0	0	0	22
People from NQ Dry Tropics/TERRAIN	3	4	2	3	2	0	2	1	0	0	0	0	17
Industry extension advisors (e.g. from SRA [BSES], Production Boards, Productivity Services group)	5	7	3	0	0	1	1	0	0	0	0	0	17
Other cane farmers	2	2	3	1	0	3	1	1	0	2	0	0	15
Researchers	4	0	2	2	2	0	0	2	3	0	0	0	15
Other. Who?*	7	2	0	1	0	0	1	1	0	1	1	0	14
Family who are also cane farmers	3	1	0	2	3	0	2	0	0	0	1	0	12
Cane Growers (the organisation)	1	0	1	2	3	2	0	0	2	0	1	0	12
Landcare	0	0	2	0	1	2	0	3	2	0	0	1	11
Other extension officers. From where?**	1	1	5	1	0	0	0	0	0	1	2	0	11
Regional cane association (e.g. from Kalamia, Invicta, Inkerman, Tully Sugar)	0	0	1	1	1	3	2	2	0	0	0	0	10
People from government departments. Which departments?	0	1	0	1	0	0	0	0	0	3	2	2	9
**Own research/knowledge (5), BBIFMAC - very helpful, practical advice rather than scientific (2), Reef Rescue (1), Researchers - you were the innovator, others come to you (1)* ***Catalyst Program (1), Farmacist (2), PSG (1)*													

In the third round data collection, land managers sought advice from industry extension, other cane farmers and others including using their own research, NRMs, the Burdekin Productivity Services, and Landcare, with one land manager highlighting that they are unable to finance handling run-off so they do not seek advice, see Table 42.

Table 42: Advice Burdekin sugar cane land managers follow when handling run-off, ranked 1 most important to 12 least important – 3rd Round Data Collection

Advisor	3rd Round												
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Industry extension advisors (e.g. from SRA [BSES], Production Boards, Productivity Services group)	9	4	3	1	0	2	0	0	0	1	1	0	**21**
Other cane farmers	4	7	3	1	1	1	0	0	1	1	1	0	**20**
Other. Who?*	9	2	0	0	1	1	0	1	0	0	0	2	**16**
Private Agronomists	4	5	4	0	0	1	0	0	1	0	0	0	**15**
Family who are also cane farmers	2	4	2	2	2	0	0	0	1	0	0	1	**14**
People from NQ Dry Tropics/TERRAIN	6	2	2	1	0	0	2	1	0	0	0	0	**14**
Cane Growers (the organisation)	1	0	2	2	1	0	1	1	0	1	2	0	**11**
Researchers	4	0	1	2	0	2	0	0	2	0	0	0	**11**
Other extension officers. From where?**	1	0	3	1	3		1			1	0		**10**
Landcare	1	4	1	0	0	1	1	0	0	0	1	0	**9**
Regional cane association (e.g. from Kalamia, Invicta, Inkerman, Tully Sugar)	0	2	0	1	0	0	1	2	1	0	0	1	**8**
People from government departments. Which departments?***	0	0	1	1	0	1	0	1	0	1	1	1	**7**

**Own research/knowledge (5), Because of the low lying nature of both my properties my options for change are limited and expensive so advice isn't relevant if grant money was available I may talk to Nq dry topics (1), Burdekin Productivity Services (1), No one, unable to finance any other option, Landcare - used their system for 25 years, no new system needed (1), We are acutely aware of the implications of our run-off and try to keep it to a minimum but understand that a closed-loop recycle system or automated irrigation could reduce run-off. Doing all of this for a low value crop is unviable in the area we farm (1).*
***Farmacist (2)*
****DAF (1)*

Attitudes and motivations associated with handling run-off

The next question asked participants how important they thought a set of listed statements were to land managers when making decisions about handling run-off. The participants were asked to choose the importance of each statement on a scale of 1-strongly disagree to 7 strongly agree, with 4 being neutral.

The first set of statements considered decision influencers when using their current system for handling run-off. The data indicates that land managers decisions were somewhat influenced by 'farmers who they respect most' in the first round (M=5.05; SD=1.96), but more neutrally influenced by respected farmers in the third round (M=4.95; SD=1.96). Although the independent t-test shows that there is no statistical difference for each statement between the rounds of data collection (see Table 43). The data indicates that land managers were more

certain in third round (M=5.36; SD=1.72) than they were in the first round (M=4.84; SD=1.90) that they followed the advice of people or organisations whose advice they think they should follow. Given that land managers indicated that their primary advisor is either a private agronomist or an industry extension officer (see Table 35 and Table 36), this may indicate a stronger compliance with best management practice. However, this will depend on if the private agronomist and/or the industry extension officer is following best practice management or not.

In both rounds of data collection land managers were neutral about statements surrounding not being able to afford to use the recommended system and that other farmers would not have the technical knowledge to handle run-off. By contrast, in both rounds of data collection, land managers disagreed that anyone was forcing them to use their current system for handling run-off, see Table 43. There were no significant difference in scores for each statement.

Table 43: Burdekin sugar cane land manager attitudes and motivations associated with calculating fertiliser application rates

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
The farmers I respect most do this	38	5.05	1.96	42	4.95	1.96
The people/organisations whose advice I follow most think I should do this	38	4.84	1.90	42	5.36	1.72
Most farmers in this region would not be able to afford to use this system for handling run-off	38	4.18	2.12	42	4.64	2.30
Most farmers in this region would not have the technical knowledge to do this	38	3.08	1.87	42	3.50	2.20
I only do this because I am forced to. Who/what is forcing you?	38	2.97	2.12	42	2.86	2.18
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

The second set of statements ask the land manager to read the statement and respond how using their method for handling run-off measures when compared to other ways of handling run-off.

All of the statements have a high agreeance except for the way that the land manager currently handles run-off being 'the least time consuming'. It is interesting to note that in the first round of data collection land managers were more neutral (M=4.95, SD=1.90) about their way of handling run-off being 'the least time consuming' than in the third round (M=5.19, SD=1.88) of data collection.

Table 44: Compared to other ways of handling run-off, what motivates sugar cane land managers in the Burdekin to use the system that you use?

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
The most effective way of controlling nutrient loss from my property*	38	6.32	0.90	42	5.69	1.65
The best way to meet my own personal goals	38	6.08	1.42	42	5.60	1.64
The best way to maintain good cash-flow	38	5.95	1.33	42	5.60	1.71
The best way to reduce business risk	38	5.79	1.44	42	5.40	1.65
The least time-consuming (or labour intensive)	38	4.95	1.90	42	5.19	1.88
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

An independent t-test highlighted a significant difference for 'the most effective way of controlling nutrient loss from my property' scores for first round (M=6.32, SD=0.90) and third round (M=5.69, SD=1.65; t(78)=2.07, p=.04, two tailed). The magnitude of difference in the means (mean difference =.30, 95% CI: .01 to .61) was small (eta squared =.02). The result indicates that while 'the most effective way of controlling nutrient loss from my property' had decreased in importance between first round and third round data collection, only 1% of the variance was explain by time between the data collection points. There was no significant difference between the other means across the two data collection periods.

Has handling run-off changed?

To establish whether there was a change in the tools that land managers use to handle run-off from rainfall or irrigation between first and third round data collection, a multiple response cross-tabulation was performed (see Table 45). The land manager unique identification number was used to identify growers in each round of data collection (1=Grower First Round and 3=Same Grower Third Round). There were 62 growers who responded to the statements in first round and 14 who responded in the third round of data collection.

There was a slight increase in land managers using recycle pits between first and third round data collection. While 70% of land managers were not capturing run-off in the first round, only 30% of land managers reported not capturing run-off in the third round of data collection. Less land managers (21.4%) reported that they had recycle pits with adequate pumping in the third round of data collection than in the first round (38.7%). About the same amount of land managers reported that they were doing something else to handle run-off in both rounds of the study. See Table 45 for examples of other ways that land managers are handling run-off. While the data in Table 45 indicates changes in the way that land managers are handling run-off, the results cannot determine if land managers are using best practice management techniques to handle run-off or some other method.

Table 45: Comparison between 'How first and third round Burdekin sugar cane land managers handle run-off from rainfall or irrigation'

Has the way land managers handle run-off from rainfall or irrigation changed?		Have you completed this survey before?		
		Grower 1st Round	Same Grower 3rd Round	Total
I have recycle pits	Count	32	9	41
	% within $Run-off	78.0%	22.0%	
	% within CompBefore	51.6%	64.3%	
	% of Total	42.1%	11.8%	53.9%
I do not capture run-off	Count	7	3	10
	% within $Run-off	70.0%	30.0%	
	% within CompBefore	11.3%	21.4%	
	% of Total	9.2%	3.9%	13.2%
I have recycle pits and have adequate pumping capacity to recycle the water	Count	24	3	27
	% within $Run-off	88.9%	11.1%	
	% within CompBefore	38.7%	21.4%	
	% of Total	31.6%	3.9%	35.5%
Other (includes sediment traps, grass and drains, buffer zones, contouring, laser levelling with silt trap, natural drainage filter)	Count	24	5	29
	% within $Run-off	82.8%	17.2%	
	% within CompBefore	38.7%	35.7%	
	% of Total	31.6%	6.6%	38.2%
Total	**Count**	**62**	**14**	**76**
	% of Total	**81.6%**	**18.4%**	**100.0%**

Percentages and totals are based on responses.
a. Dichotomy group tabulated at value 1.

Other Innovative Run-off Practices

Land managers were asked if they used any other innovative practices to manage nitrogen and/or run-off. Nearly 58% of land managers selected 'yes' that they thought they were using innovative practices in first round data collection and 40.5% selected yes in the third round. The land managers were asked to write down the innovative practices that they were using. The responses were coded and matched to the ABCD Framework, see Table 46 for coded responses. When matching responses to the ABCD Framework, most of the practices that land managers noted met best management to aspirational practice expectations. A list of anecdotal comments written by land managers describing the innovative practices they use are included in Appendix 4.

Table 46: Other innovative practices used by Burdekin sugar cane land managers - anecdotal comments coded (see Appendix 4 for examples)

		1st Round		3rd Round	
		n	**Percent**	**n**	**Percent**
Yes		22	57.9	17	40.5
No		16	42.1	25	59.5
Total		38	100	42	100
Coded Responses to Innovative Practices (see examples in Appendix 4)	**ABCD Framework**	**1st Round**		**3rd Round**	
		n	**Percent**	**n**	**Percent**
Fertiliser/Bio Fertiliser	B - A	5	25.0	3	21.4
Alternative Crops/Irrigation		3	15.0	4	28.6
Headlands/Drains/Recycle Pits		0	0.0	2	14.3
Stool Splitting/Mixed Method		6	30.0	1	7.1
Best Management Practices		2	10.0	1	7.1
Applied Humates		2	10.0	1	7.1
Automated Flood System		1	5.0	1	7.1
		1	5.0	1	7.1
		20	**100**	**14**	**100**

6.3.2.6 Perceptions of Causes and Pressure on Water Quality

Land managers were asked to agree (7) or disagree (1) with a statement about how nutrient loss impacts water quality in local streams, rivers and waterways. They could also select that they did not know or were unsure how local streams, rivers and waterways were impacted (8) or neutral (4).

A means analysis shows that overall land managers held a neutral view to the statement about whether or not nutrient loss from their property has an impact on local streams, rivers and waterways.

Table 47: Means analysis of Burdekin sugar cane land managers to the statement about how nutrient loss impacts water quality from the Burdekin region

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
Nutrient loss from my property has no impact on water quality in local streams, rivers & waterways	38	4.82	1.96	42	4.52	2.31
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

A frequency analysis indicates that land manager's attitude towards nutrient loss from their property having no impact on water quality in local streams, rivers and waterways has changed over time. Less land managers agreed with the statement in the third round (38.1%) of the study when compared to the first round (63.2%), indicating that they do recognise that nutrient loss is having an impact on water quality in local streams, rivers and waterways. However, the number of responses to 'neutral' and 'don't know/not sure' have also increased, indicating uncertainty amongst land managers.

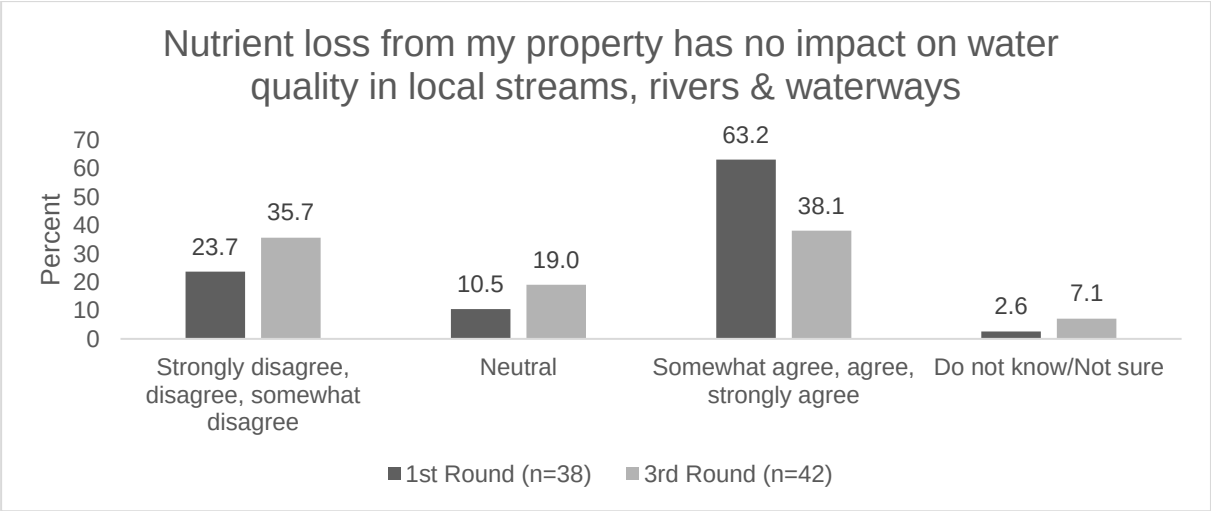

Figure 5: Responses from Burdekin sugar cane land managers about nutrient loss from their property impacting local streams, rivers and waterways

When asked what Burdekin land managers thought were the top two causes of poor water quality in local streams, rivers and waterways, they responded that the top cause was farming, in both first round (37.1%) and third round (30%) data collection. The second top cause in first round data was listed as weeds (59.3%) and in third round data the second top cause was listed also as farming (26.3%). Interestingly, in third round data collection, salinity was nominated as a top cause of poor water quality in local streams, rivers and waterways. In particular, farming was identified as banana, grazing, fruit growing, hobby farmers, cane farming and excess nutrients, chemicals and pesticides that come from farming. In both rounds of data collection, a small percentage of land managers commented that there was no poor water quality in the first round data collection, but not in the third round of data collection. Congruent with first round data reporting (Farr et al., 2017c), the data indicates that land managers in Burdekin cane industry may be shifting the blame for the causes of poor water quality to other farmers. Interestingly, very little blame is attributed to urban development, which is often cited by land managers as the main cause of poor water quality in the GBR Basin, see Appendix 8 for anecdotal land manager comments, which were coded into themes.

Table 48: Two top causes of poor water quality in local streams, rivers and water ways – Burdekin

	1st Round				3rd Round			
	Cause 1		Cause 2		Cause 1		Cause 2	
	n	Percent	n	Percent	n	Percent	n	Percent
Farming (Banana, Cane, Grazing and Fruit Growing)	13	37.1	5	18.5	12	30.0	5	26.3
Run-off	7	20.0	2	7.4	4	10.0	1	5.3
Weather/Natural Run-off/Floods/Rainfall	3	8.6	2	7.4	5	12.5	3	15.8
No poor water quality	3	8.6	0	0.0	2	5.0	0	0.0
Weeds	3	8.6	16	59.3	7	17.5	2	10.5
Urban Development	2	5.7	1	3.7	0	0.0	1	5.3
Feral Animals (Pigs)	1	2.9	0	0.0	0	0.0	0	0.0
Other Industry or Government	1	2.9	1	3.7	0	0.0	1	5.3
Blockages in creeks, clearing creeks and drains	0	0.0	0	0.0	0	0.0	2	10.5
Erosion	0	0.0	0	0.0	1	2.5	0	0.0
Bare ground	0	0.0	0	0.0	0	0.0	1	5.3
Salinity/Calcium	0	0.0	0	0.0	8	20.0	1	5.3
Don't know	2	5.7	0	0.0	1	2.5	2	10.5
Total	**35**	**100**	**27**	**100**	**40**	**100**	**19**	**100**

Next land managers were asked to strongly agree (7) or strongly disagree (1) with a statement about the role that cane-growing plays in the declining health of the Great Barrier Reef (GBR). Land managers could also select that they did not know or were unsure (8) or neutral (4) about what role cane growing plays in the declining health of the GBR.

A means analysis indicates that overall in first round data collection, land managers somewhat agreed that cane growing plays almost no role in the declining health of the Great Barrier Reef. Whereas, third round data indicates a more neutral stance to the statement.

Table 49: Means analysis of Burdekin sugar cane land manager statement about the role cane growing plays in the declining health of the Great Barrier Reef

	1st Round			3rd Round		
	n	Mean	SD	n	Mean	SD
Cane-growing plays almost no role in the declining health of the Great Barrier Reef	38	5.05	1.58	42	4.60	1.82
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

A frequency analysis of the same data shows less agreeance with the statement in third round data collection than in first round data collection. This may indicate a change in attitude towards the role that cane growing plays in the declining health of the Great Barrier Reef by Burdekin cane farmers i.e. that cane growing may play some role in the declining health of the GBR.

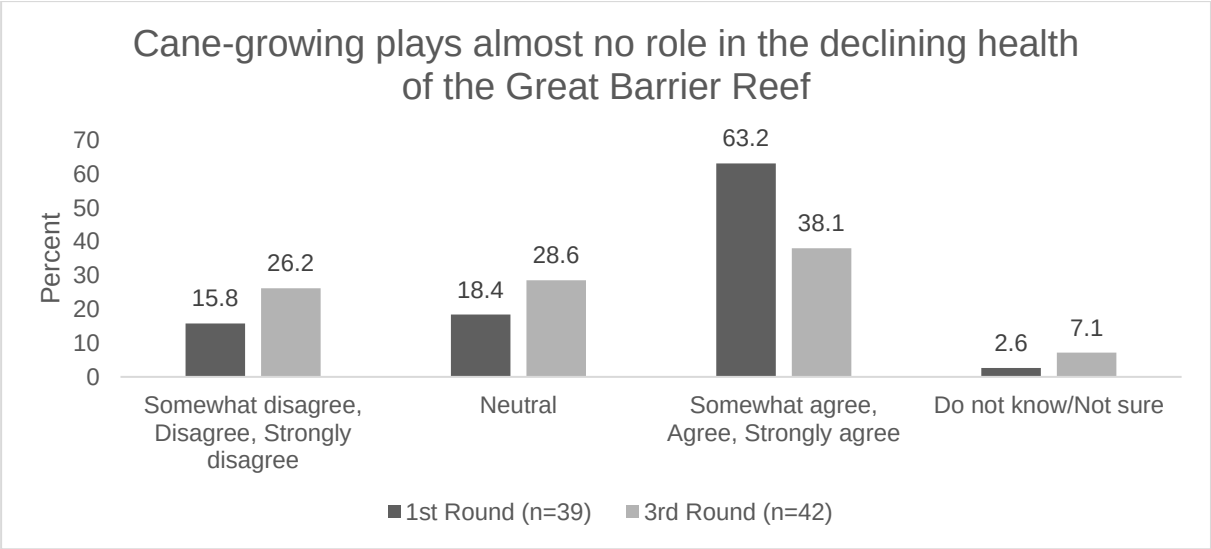

Figure 6: Responses from Burdekin sugar cane land managers about the role cane growing plays in the declining health of the Great Barrier Reef

Participants were asked to write comments about what they thought the two top pressures were on the GBR. Land manager responses were coded into themes, a full list of anecdotal comments can be found in Appendix 9. In the first round of data collection Burdekin cane growers listed climate change/global warming (rising sea temperatures, water temperature) as the main pressure on the GBR. The second top pressure was also listed as climate change. In the third round of data collection climate change was listed as the top pressure and urban development as the second top pressure on the GBR. These results support earlier findings (Farr et al., 2017d, p. 77) that land managers tend to shift the blame related to water quality and the health of the Great Barrier Reef to climate change, natural weather events, run-off not related to farming, fishing, shipping, tourism and urban development rather than consider their own practices as adding pressure to the GBR.

Table 50: Burdekin - two top pressures on the health of the Great Barrier Reef

	1st Round				3rd Round			
	Pressure 1		Pressure 2		Pressure 1		Pressure 2	
	n	Percent	n	Percent	n	Percent	n	Percent
Climate Change/Global Warming	8	22.9	8	32.0	13	31.7	2	5.6
Weather/Natural Run-off/Floods/Rainfall	5	14.3	3	12.0	2	4.9	4	11.1
Run-off	5	14.3	2	8.0	3	7.3	4	11.1
Fishing/Shipping/Tourism	4	11.4	0	0.0	4	9.8	4	11.1
Urban Development	3	8.6	4	16.0	3	7.3	9	25.0
Farming (Banana, Cane, grazing and Fruit Growers)	3	8.6	3	12.0	3	7.3	4	11.1
Acidification/CoT/Coral Bleaching	2	5.7	1	4.0	1	2.4	1	2.8
Feral Animals (Pigs)	1	2.9	0	0.0	0	0.0	0	0.0
Other Industry, Mining, Government, Research	1	2.9	3	12.0	5	12.2	1	2.8
No poor water quality	1	2.9	0	0.0	0	0.0	0	0.0
Illegal dumping/Accidental Spills/Pollution	1	2.9	0	0.0	4	9.8	3	8.3
Erosion	0	0.0	0	0.0	0	0.0	1	2.8
Cultivation Practices	0	0.0	1	4.0	0	0.0	0	0.0
Blockages in creeks, cleaning creeks and drains	0	0.0	0	0.0	0	0.0	1	2.8
Construction/Civil Works	0	0.0	0	0.0	0	0.0	0	0.0
Don't know	1	2.9	0	0.0	3	7.3	2	5.6
Total	**35**	**100**	**25**	**100**	**41**	**100**	**36**	**100**

6.3.2.7 Sugar Cane Land Managers Results Summary

This section has reported on results from questions related to nutrient and run-off management practices for growing sugar cane in the Burdekin region, of Queensland Australia.

The results from the analysis show that cane farmers in the Burdekin region have moved from a goal of maximizing productivity and efficiency and improving farming practices for profit and environment to increasing viability and financial security and improving productivity and/or efficiency in farming.

When making decisions to reach their goals, land managers decisions are significantly influenced by learning and testing new ways of doing things on the farm or property and by leaving the farm in better condition than it was when the land manager got there. Burdekin cane farmer's decisions are also significantly influenced by safeguarding local waterways, native plants and animals and the Great Barrier Reef. While maintaining health, spending time with family and friends, maintaining relations with other land managers, and being able to make their own decisions were also important, they were not seen as influencers to decision making for cane farmers in the Burdekin. Likewise, financial statements about keeping farming cost low, maximising profits, minimising risk, keeping a steady cash flow and servicing debt were also important, but did not influence decisions more in the third year of the study compared to the first year.

Nearly all of the land managers were using some form of irrigation practices. The amount of water used varied and depended on the soil type and season. More than ninety percent of the land managers reported having zero to 25 percent irrigation run-off from their property. While the percent of responses was lower (<15%), more land managers reported having between 25 and 50 percent of irrigation run-off from their property in the third year of the study than in the first.

When considering irrigation management tools, more than half of respondents were using their own experience to make choices about irrigation tools and their management. In the third year of the study, seventy percent of land managers were using soil moisture probes. Of which, forty percent of land managers were using newer technology (g-dots) to identify water use and predict next irrigation. The vast majority of land managers expected that they would use the same systems next year.

Land managers have reported differently about whose advice they follow. In the first year of the study, land managers were following advice about irrigation practices from various advisors including other cane farmers, private agronomists, researchers, industry extension advisors and family who are also cane farmers. In the third year, there was a more distinct group of advisors including private and industry agronomists and family who are also cane growers. Land managers also listed other industries and government departments as 'other' advisors. It is important to note the influence that networks have on land manager decisions. These networks may be identified as either positive or negative and may become enablers or barriers to practice change. The findings support previous recommendations for a land manager network analysis to ensure that information gatekeepers and opinion leaders influence future water quality communication strategies (see Hay & Eagle, 2018).

When thinking about scheduling irrigation, Burdekin cane farmer's decisions are influenced by the farmers that they respect most and how they are scheduling their irrigation. Land managers from the Burdekin region indicated that they were not certain that most farmers in the region would have the technical knowledge to schedule irrigation, although they indicated that most other land managers would be able to afford the systems. Land managers disagreed that they were being forced to make the decisions they were making about irrigation scheduling practices. This is expected, given that most land managers reported that they follow their own experience for scheduling irrigation, but the sentiment may also be influenced by new and affordable technologies that are available to indicate when irrigation is required e.g. G-Dots.

The majority of Burdekin cane farmers agreed that the system that they were using to schedule irrigation was the most effective way of controlling nutrient loss from their property. However, the results indicate that land managers in the third round of the study compared to the first year of the study, remain neutral or slightly disagree that the scheduling tools that they are using are the most effective way of controlling nutrient loss from their property. The results may indicate a loss of confidence in the current tools used for scheduling irrigation or an uncertainty in the new tools being used, further investigation is required.

Burdekin cane farmers are tailoring their fertilizer rates to different parts of their property in the third year of the study more so than in the first year and they are doing it under the influence of their trusted advisor. However, less land managers identified as using best management

practice in the third year of the study compared to the first year. When calculating fertilizer rates, land managers are somewhat influenced by the farmers they respect most and the people and organisations that think they should be using the system to calculate fertiliser rates. However, they thought that the system they are using is the most effective way to control nutrient loss from their property.

When comparing the same land managers in first and third year data collection, the data indicates that there has been a change in the way land managers calculate fertiliser application rates. Slightly more land managers in the third year of the study are using their advisor to calculate fertiliser application rates than in the first year of the study. Less land managers reported using more fertiliser on high yielding blocks, while more are estimating fertiliser rates from farm yield. Nearly two thirds of land managers reported tailoring their fertiliser rates. However, of concern is that less land managers are using industry standard rates for district yield potential in third round (15.4%) compared to first round (25.5%) data collection? While the data indicates changes in the way that land managers are calculating their fertiliser application rates, the results cannot determine if land managers are using best practice management techniques to calculate fertiliser rates or some other method. In addition, the sample is very small and therefore not representative of the entire Burdekin region.

When handling run-off, just over one third of land managers are following conventional run-off management practices or using other practices (buffer zones, grass and drains, contouring and silt traps), which meet minimum expectations or are current practices as promoted by the industry. The data indicates that land managers decisions about handling run-off were somewhat influenced by 'farmers who they respect most' in the first round, but more neutrally influenced by respected farmers in the third round and that they follow the advice of people or organisations whose advice they think they should follow. Given that land managers indicated that their primary advisor is either a private agronomist or an industry extension officer, this may indicate a stronger compliance with best management practice. Compliance will depend on if the private agronomist and/or the industry extension officer is following best practice management or not. Significantly, land managers reported that the method they used to handle run-off was the most efficient way to control nutrient loss from their property.

When comparing the same land managers who completed the survey in the first round and again in the third round, the data showed that there has been minor changes in the way that land managers are handling run-off. More land managers are using recycle pits and capturing run-off. However, less land managers reported using recycle pits with adequate pumping capacity to recycle water. Around the same amount of land managers reported doing something other than what was listed to handle run-off, including sediment traps, grass and drains, buffer zones, contouring or lazer levelling with silt traps or they are using natural drainage filters. While the results indicate changes in the way that land managers are handling run-off, the results cannot determine if land managers are using best practice management techniques to handle run-off or some other method.

Around half of the land manager respondents identified that they were using other innovative practices to manage nitrogen and/or run-off. When matching responses to the ABCD Framework, it was identified that most of the practices that land managers noted when selecting an 'other' practice, met best management to aspirational practice expectations in the third round of data collection.

Overall the land managers surveyed neither agreed nor disagreed that nutrient losses from their property have an impact on local streams, rivers and waterways. On closer inspection, in the third round, the data shows that less land managers agreed that nutrient loss from their property has no impact on water quality, indicating an acknowledgment that nutrient loss from their property did have some impact on water quality in local streams, rivers and waterways.

When asked what the top two causes of poor water quality in local streams, rivers and water ways were, first round land managers cited farming (banana, cane, grazing and fruity growing) and weeds. In the third round land managers cited farming to be both the top and second top cause of poor water quality in local streams, rivers and waterways.
Overall land managers in first round somewhat agreed that cane growing plays almost no role in the declining health of the Great Barrier Reef. Whereas, third round data indicates a more neutral stance to the statement.

Participants identified climate change and global warming as the top two pressures on the health of the GBR in first round and in third round of the study, followed by urban development in both rounds.

6.3.3 Burdekin Grazing Nutrient and Run-off Management Practices, Results from Round 3 Land Managers Survey

6.3.3.1 Factors that influence land manager decisions

In order to understand the factors that influence their decisions, land managers were asked to identify the two most important things that they hoped to achieve for their farm or property.

Land managers responses were coded into first round and third round data, which resulted in the same goals over the duration of the study. Grazing land manager's main goals are to have a sustainable and viable grazing business, to pass the property on to future generations in a better condition than when they found it by improving pastures, groundcover and reducing weeds, highlighting a motivation to participate in good farming practices.

Table 51: Burdekin grazing land managers personal goals to achieve on farm/property

Goal 1	Goal 2
Sustainable and viable grazing business	Improving the land, leave the country better than when we found it
Pass on a healthy property to future generations	Pass on a productive property to next generation
Improving pastures, groundcover, reducing weeds	Sustainable grazing business

6.3.3.2 Decision making drivers

The next question asked land managers how important they thought a set of 21 statements were when making decisions about what to do on their farm or property (See Table 52). The participants were asked to choose the importance of each statement on a scale of 1-extremely unimportant to 8 where 7 was equal to extremely important (essential) and 8 was equal to 'I don't know', the number 4 was listed as neutral. A means test was applied to compare first and third round land manager responses. Followed by an independent samples t-test to

establish any significant difference in the responses. The following section reports on the results from Table 52.

Family, friends and other land manager influences

The first set of statements considers family, friends, health and other land manager influences when making decisions. All of the statements were more important in the third round of data collection than they were in the first round, except for 'maintaining traditions and heritage', which remained the same. While 'maintaining physical and mental health of family' was selected as important to extremely important, by contrast, land managers selected 'maintaining traditions and heritage' as being less important, rating the statement between neutral and somewhat important when making decisions on their farm or property. An independent t-test showed that none of the statements were statistically different between data collection points, see Table 52.

Financial influencers

Statements that considered financial influences i.e. minimising risk, maximising profits and keeping a steady cash flow were indicated as important to very important. However, similar to sugar cane responses, grazing land managers rated them as less important to consider when making decisions about what to do on the farm in the third round of data collection compared to the first round data collection. Keeping farming cost low and servicing debt moved from somewhat important to important in the third round of data collection compared to the first round. There was no statistical difference for decision influencers between data collection points, see Table 52.

Land management influencers

The next set of statements consider land management influences when making decisions. There is a statistical difference between first and third round data collection in one land management statement. Land managers felt that 'having time to pursue hobbies' was more important in third round data (M=5.01; SD=1.72) than in the first round (M=4.26, SD=1.91; t(139)=2.47, p=.01, two tailed) when making decisions about what to do on their property. While the other statements were identified as more important in third round compared to first round, there was no statistical difference between statements over the data collection points. Similar to Burdekin sugar cane land managers, 'being able to make their own decisions about their farm/property' was the most important for graziers in the first and third round of data collection. 'Having efforts recognised by the wider community' was the least important consideration in both first and third round data collection for grazing land managers when making decisions about what to do on their properties. There was no statistical difference for decision influencers between data collection points, see Table 52.

Farming practices

When considering how farming practices influence decisions, all of the statements were less important in the third round of data collection compared to the first round. While rated as important to very important, the scores show that leaving the farm in better condition is slightly less important in third round data collection than it was in first round data collection. While maintaining or improving water supplies and storage and minimising sediment run-off or nutrient losses were rated as important to very important, there is no statistical difference between land manager responses in the first round to the third round, indicating that these

factors are always considered important to decisions about what to do on the land managers farm or property, see Table 52.

Safeguarding local waterways, native plants and animals and the Great Barrier Reef

The final set of statements indicate that safeguarding local waterways, the Great Barrier Reef (GBR) and native plants and animals are more important to land managers in the third round of data collection compared to the first round. There is a statistical difference between first round and third round data for two of the three statements. Helping to safeguard native plants and animals (first round M=5.63; SD=1.56 and third round (M=5.82, SD=1.20; t(139)=2.13, p=.03, two tailed) and Helping to safeguard the Great Barrier Reef (first round M=5.44; SD=1.79 and third round (M=5.99, SD=1.26; t(139)=2.15, p=.03, two tailed) both increased in importance between data collection points. While the level of importance of land manager decision influencers about what to do on the farm or property has increased between first and third year data collection, the statements about safeguarding native plants and animals and helping to safeguard the GBR are more significant than safeguarding local water ways, see Table 52.

Table 52: Burdekin sugar cane land manager responses decision making drivers

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
Maintaining physical and mental health of family	62	6.50	0.99	79	6.58	1.15
Spending face-to-face time with family and friends	62	5.95	1.12	79	6.24	1.06
Maintaining good relations with other farmers/graziers in the local area	62	5.71	0.88	79	5.92	1.05
Keeping in contact with family and friends in other ways (e.g. via phone, through social media)	62	5.61	1.41	79	5.96	1.24
Maintaining family traditions and heritage	62	4.66	1.70	79	4.66	1.93
Minimising risk (of very high costs or very low income)	62	6.32	0.95	79	6.28	1.07
Maximising farm profits (income minus costs)	62	6.29	1.14	79	6.19	1.21
Keeping a stable (steady) cash-flow	62	6.18	1.12	79	6.08	1.39
Keeping farm costs low	62	5.92	1.06	79	6.13	1.16
Servicing debt	62	5.95	1.53	79	6.14	1.44
Being able to make your own decisions about your farm/property	62	6.44	0.99	79	6.56	1.00
Learning about and testing new ways of doing things on your farm/property	62	5.89	1.28	79	6.11	1.13
Sharing new ideas with others	62	5.35	1.28	79	5.61	1.31
Having time to pursue hobbies*	62	4.26	1.91	79	5.01	1.72
Having efforts recognised by the wider community	62	3.73	1.87	79	4.32	1.84
Leaving the land/farm in better condition than it was when you first started managing it	62	6.66	0.70	79	6.65	0.93
Maintaining/improving water supplies and storages	62	6.58	0.69	79	6.57	1.00
Minimising sediment run-off and/or nutrient losses	62	6.34	1.04	79	6.52	0.96
Helping to safeguard local waterways	62	5.92	1.26	79	6.33	1.02
Helping to safeguard native plants and animals*	62	5.63	1.56	79	5.82	1.20
Helping to safeguard the Great Barrier Reef*	62	5.44	1.79	79	5.99	1.26
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

6.3.3.3 Pasture spelling practices

Land managers were asked to answer a series of questions about their pasture spelling practices. The responses from the first round of data were compared to responses from the third round of data to identify any changes in pasture spelling practices.

When asked if respondents spelled their paddocks during the most recent wet season, the majority in both first and third round data collection selected that they did spell their paddocks in the most recent wet season.

The majority of land managers selected that they were spelling about ¼ of their paddocks during the wet season, however less (23.9%) were practicing the method in the third year compared to in the first year (38.5%), see Table 53. Approximately 69% of respondents chose the response that they spelled their paddocks for three months or more and 23% chose two months or more. The remainder spelled their paddocks for four weeks or less.

Table 53: Proportion of paddocks that were spelled by Burdekin Grazing Land Managers in the most recent Wet Season

	1st Round		3rd Round	
	n	**Percent**	**n**	**Percent**
All	8	20.5	6	13.0
About ¾	5	12.8	7	15.2
About ½	6	15.4	16	34.8
About ¼	15	38.5	11	23.9
Less than ¼	5	12.8	6	13.0
Total	**39**	**100**	**46**	**100**

Respondents were asked to add comments about their spelling practices and about if they planned to use the same spelling practice next year. Nearly 90% of the respondents indicated that they would do the same in the next year. Two percent said they would not do the same practice next year and nearly 6% said that they would do something different, as indicated in Table 54.

Table 54: Anecdotal comments about what Burdekin grazing land managers plan to do differently when spelling paddocks next year

1st Round	3rd Round
Hoping to sell enough cattle to be able to set up one more trough and do internal fencing to be able to spell paddocks	Prep before more cattle
More intensive grazing and more regular spelling (or for longer periods)	Still going to spell, but going to hit them a bit harder.
Next time, looking to burn them [the paddocks] if the opportunity presents itself	The same but for a longer period

Table 55 lists the responses from the Burdekin grazing land managers about how they spelled their paddocks in the most recent wet season.

Table 55: Anecdotal Responses from Burdekin Graziers about how they spell their paddocks

1st Round	3rd Round
• 60% Reduced 01/13. 95% Reduced 01/15.Destocked 03/16 • Available funds are being used on weed spraying expenses and don't have the money to put up internal fencing • Cattle are on rotation moved every four days during growing season • Every paddock is spelled for 100 days 3 times per year - That's 300 days approx. per year • Every year is unique - flexibility is key • I spell 25% of the property every year. This used to be for a full wet season. I am now going into a rotational grazing strategy, so this will involve more country being spelled more often but also grazed more intensively for shorter periods. • Some, depends on season. Some rotational, spelling etc. • Various, cattle in one mob, move in high density groups spelling some paddocks for up to 12 months • We are trying to implement this, but no rain for 4 years, and lack of funds to fence more paddocks off is not helping • Yes, I have been spelling paddocks during the wet for the last 25 yrs. • We use rotational grazing systems on this property. We have employed this practice for 20 years and during this time, we have been able to manage Parthenium and other invasive weeds quite well and move from a very degraded pasture state when we took over management, to a very good to excellent pasture at present. A result of our management practices saw the CSIRO conduct a ground-truthing case study on our property a couple of years back as they could see an improvement in our groundcover over the past 20 years. We like to spell a paddock (sometimes up to 6 months or more, depending on the season). Once the grasses have seeded, it is quite safe to graze. How long each paddock is grazed depends entirely on the season. We do not run our property to full capacity as we like to have at least 2 paddocks per herd of cattle as this allows us to rotationally graze. Rainfall has a lot to do with our rotational grazing pattern and drought really has an impact.	• ~70% of our property is spelled at any one time, for an average of ~5 months. • Depending on soil type, fencing paddocks according to soil type, • Been in drought for years; did some spelling on some paddocks; • Can't remember the last wet season we had. Have juggled our cattle the best way we can to get through lack of rain. • 80% of my property has no cattle at one time • Depends on amount of rain and out compete the weeds-depend on seasonal conditions-90 days/year • Essential management practice • Does Cell Grazing - Every paddock gets spelled most of the year. • Haven't had a wet season for nearly 5 years • Latest season there was nothing to spell. Typically we would. If there was rain. • No need to spell if they are not overstocked only spell after a fire or ploughed • Not in the past couple of years but it is a practice that I to do • Our stock is on a rotation. We do spell certain paddocks for the time when Chinese apple have fruit. • Rotational graze to utilise new growth in peak growing season • Rotational grazing over wet season spelling • Spelling during growing season is vital. We try to rotate different paddocks to spell each year • We graze only 1 paddock at a time, other 6 paddocks are rested • We shut up our dam squares, stops cattle from going to their habitual grazing • When you are spelling paddocks a graze in the wet season is just as important been rotating for 25 years • Yes. Each paddock is spelled according to its Stock Days per Hectare per 100mm of rainfall and ground truthed by pasture monitoring during each rotation. Currently we aim to rest each paddock for approx. 240 days per year. • Yes. Rotate the paddocks. Always spelled.

Advice land managers follow when making decisions about paddock spelling

Land managers were asked to rank from 1= most important to 13=least important whose advice they follow most when spelling paddocks. A cross tabulation between ‘advice land

managers follow when spelling paddocks' and 'round of data collection' compared responses from the first and third rounds of data collection, see Table 56 and Table 57.

In the first round of data collection the respondents identified 'Other graziers' as their most important advisor, followed by 'Other. Who?' for which respondents listed trusted advisors as 'them self or their partner', 'consultants', 'trials and education programs' and holistic graziers and educators, other successful graziers and grazing best practice and local council/ authorities that at not natural resource management groups. 'Family who are also graziers' was ranked as the third most important advisor. The next most important advisors were NQ Dry Tropics and other extension officers, see Table 56 for a list of extension other extension officers.

Table 56: Advice Burdekin grazing land managers follow when making decisions about paddock spelling, ranked 1 most important to 13 least important – 1st Round Data Collection

Advisor	**1st Round**													
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Total**
Other graziers	10	9	5	2	2	0	0	0	0	0	0	0	0	28
Other. Who? *	14	4	3	1	1	0	0	0	0	0	0	1	1	25
Family who are also graziers	20	1	0	0	0	1	0	0	0	0	0	0	0	22
People from NQ Dry Tropics	6	6	3	3	0	0	0	0	0	0	0	0	0	18
Extension officers. From where? **	3	3	4	3	1	0	0	0	0	0	0	0	0	14
Researchers	1	1	6	2	1	1	0	0	0	0	0	0	0	12
Landcare	1	3	1	3	0	0	0	0	0	0	0	0	0	8
Meat & Livestock Australia	2	1	2	1	0	0	1	0	0	0	0	0	0	7
People from government departments. Which departments? ***	1	2	1	1	0	0	0	0	1	0	0	1	0	7
Agforce	2	0	0	2	0	0	0	0	1	0	0	0	0	5
Private Agronomists	1	1	0	1	1	0	0	0	0	0	1	0	0	5
Non-farming family/friends	1	0	1	0	0	0	0	1	0	0	0	0	0	3
QLD Farmers Federation	1	0	0	1	0	0	0	0	0	1	0	0	0	3

**Other. Who? (number of responses): their own experience (11); consultants e.g. Resource Consulting Services (8); trials/education programmes (2); holistic management graziers/educators (1); other successful graziers (1); grazing best practice (1); local council/authority, not NRM (1)*
***Other Extension, from where?: DAF (6); NQDT (2); Department of Natural Resources (2); CSIRO (1); Northern Gulf Resource Group (1)*
****Government Departments: DAF/DPI (2)*

In the third round of data collection the most trusted advisor was also identified as 'family who are graziers' and 'other graziers' as well as "Other. Who?" which were listed as their 'own experience', 'consultants', 'trials and education' and 'holistic management graziers/ educators' and 'other successful graziers' and 'industry representatives and government departments'. People from NQ Dry Tropics ranked as the fourth advisor most followed when making decisions about spelling paddocks (see Table 57).

Table 57: Advice Burdekin grazing land managers follow when making decisions about paddock spelling, ranked 1 most important to 13 least important – 3rd Round Data Collection

Advisor	3rd Round													
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Total**
Family who are also graziers	21	9	4	1	1	0	0	1	0	0	1	0	0	38
Other graziers	14	12	6	3	2	0	0	0	0	1	0	0	0	38
Other. Who?	28	5	0	1	0	1	0	0	0	0	0	2	2	39
People from NQ Dry Tropics	8	8	5	3	5	1	2	1	0	0	0	0	0	33
People from government departments. Which departments?	1	3	5	2	0	0	1	1	0	1	0	4	1	19
Extension officers. From where?	3	3	3	2	3	1	0	0	0	1	1	1	0	18
Researchers	2	2	3	3	1	0	2	1	1	0	1	0	0	16
Meat & Livestock Australia	1	1	3	1	0	2	2	2	3	0	0	0	0	15
Landcare	0	1	1	3	1	3	0	1	1	0	2	0	0	13
Agforce	0	1	0	2	1	1	0	2	0	3	1	0	0	11
Private Agronomists	1	3	1	0	0	1	1	0	0	0	0	3	0	10
Non-farming family/friends	0	2	0	0	0	0	0	0	0	0	3	3	0	8
QLD Farmers Federation	0	0	0	0	1	1	0	0	1	1	2	1	1	8

**Other. Who? (number of responses): their own experience (17); consultants e.g. Resource Consulting Services (9); trials/education programmes (2); holistic management graziers/educators (1); other successful graziers (1); dependent on rainfall (1); industry representatives (1)*
***Other Extension, from where?: DAF (7); NQDT (1).*
****Government Departments: All of them (1), DPI (1)*

Non-farming family and friends, the Queensland Farmers' Federation (QFF) and private agronomists were ranked as least important advisors to follow when making decisions about spelling paddocks during the wet season. Land managers who selected 'People from government departments. Which departments? also commented negatively about the departments level of knowledge at a policy level reinforcing the lack of trust of government agencies (see Eagle et al., 2016b).

> *"Not at all!! They have NO IDEA!! NPRSR & the forestry dept. are dangerously idealistic & ignorant of actual outcomes for the land" ranked least likely to follow advice by land managers.*

> *"State and Federal Governments. The ministerial misuse of information gathered from our properties has made these departments untrustworthy. The staff are not at fault - their political policy directors are destroying a once very trusted source of information" ranked least likely to follow advice by land managers.*

Attitudes and motivations associated with pasture spelling practices

The next question asked participants how important a set of listed statements were to land managers when making decisions about pasture spelling practices. The participants were asked to choose the importance of each statement on a scale of 1-strongly disagree to 7 strongly agree, with 4 being neutral.

The first set of statements considered influencers when making decisions about pasture spelling practices. Burdekin graziers follow their chosen pasture spelling practice because the people or organisations whose advice they follow most think that they should use the spelling practice (first round M=5.56, SD=1.99; third round M=5.28, SD=1.86). The data indicates that land managers decisions about pasture spelling practices are also somewhat influenced by 'graziers that they respect' in both first (M=5.26, SD=1.78) and third round (M=5.72, SD=1.46) data. The data (first round M=4.26, SD=2.35; third round M=4.16, SD=2.28) indicates that graziers held a neutral stance on whether other graziers could afford the systems being used for pasture spelling. Similarly, they offered a neutral stance about their thoughts on other graziers having the technical knowledge to implement the current pasture spelling practices (first round M=4.06, SD=1.99; third round M=4.22, SD=1.97). Land managers did not agree that they were being forced to use the methods, see Table 58. An independent t-test produced no significant difference in scores for each statement.

Table 58: Burdekin grazier land manager attitudes and motivations associated with pasture spelling practices

	1st Round			3rd Round		
	N	**Mean**	**SD**	**N**	**Mean**	**SD**
The people/organisations whose advice I follow most think I should do this	54	5.56	1.99	74	5.28	1.86
The graziers I respect most do this	54	5.26	1.78	74	5.72	1.46
Most graziers in this region would not be able to afford to do this	54	4.26	2.35	74	4.16	2.28
Most graziers in this region would not have the technical knowledge to do this	54	4.06	1.99	74	4.22	1.97
I only use this system for spelling paddocks during the wet season because I am forced to. Who/what is forcing you?	54	2.98	2.51	74	2.26	2.01
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

The second set of statements ask the land manager to read the statement and respond how using their method for pasture spelling practices measures when compared to other ways of managing pasture spelling practices.

While all statements have high agreement (see Table 59) 'the best way to meet my own personal goals' and 'the most effective way of controlling erosion on my property' are the most agreed with motivators for using the method to spell paddocks that the land manager is using. Grazing land managers agreed that 'reducing business risk' and 'maintaining good cash-flow' were also considered when thinking about the system for spelling paddocks or not during the wet season. While being time consuming or labour intensive were neutral to motivation. An independent t-test produced no significant difference in scores for each statement.

Table 59: Compared to other ways of managing pasture spelling, what motivates Burdekin grazier land managers to use the system that they use?

	1st Round			3rd Round		
	N	**Mean**	**SD**	**N**	**Mean**	**SD**
The best way to meet my own personal goals	54	6.09	1.39	74	6.04	1.12
The most effective way of controlling erosion on my property	54	5.80	1.59	74	5.66	1.62
The best way to reduce business risk	54	5.78	1.36	74	5.82	1.22
The best way to maintain good cash-flow	54	5.59	1.52	74	5.70	1.37
The least time-consuming (or labour intensive)	54	4.43	1.97	74	4.91	1.87
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

Has pasture spelling practices changed?

To establish whether there was a change in the way land managers manage pasture spelling between first and third round data collection, a multiple response cross-tabulation was performed using the land manager unique identification number to identify graziers in each round of data collection (1=Grazier First Round and 3=Same Grazier Third Round). However, the number of graziers who completed the survey in both rounds was too small to draw conclusions from the analysis.

Adjusting stock rates to paddock conditions practices (other than wet-season spelling)

Land managers were asked to answer a series of questions about adjusting stock numbers to paddock conditions. The responses from the first round of data were compared to responses from the third round of data to identify any changes in adjusting stock numbers.

Graziers in the Burdekin are adjusting stock numbers in both first round (96.3%) and third round (90.4%) data collection. Around 90% of graziers in first round and 89% of graziers in third round have an end-of-season target for pasture condition.

The majority of graziers aim to leave between one third and one half of the feed that was grown that season in the paddock at the end of the season. Graziers mostly achieve these targets between five and seven years in every ten years. The vast majority of graziers in first round (94.4%) and third round (90.4%) plan to adjust stock numbers to manage pasture the same way next year (Table 60).

Table 60 also lists management practices for those graziers that intend to do something different in the coming year.

Table 60: Burdekin grazier intentions for adjusting stock rates to paddock conditions (other than wet season spelling)

	ABCD Framework	1st Round		3rd Round	
How much feed to you aim to leave in the paddock at the end of the season?		**n**	**Percent**	**n**	**Percent**
Less than 1/3 of the feed that was grown that season	C	3	6.1	12	18.5
Between 1/3 and 1/2 of the feed that was grown that season	C/B	37	75.5	44	67.7
Between 1/2 and 3/4 of the feed that was grown that season	B	8	16.3	8	12.3
More than 3/4 of the feed that was grown that season	B/A	1	2.0	1	1.5
		1st Round		**3rd Round**	
Roughly how often do you achieve this?		**n**	**Percent**	**n**	**Percent**
Less than 3 in 10 years	C	8	16.3	10	15.4
Between 5 and 7 years in 10	C/B	16	32.7	19	29.2
Between 3 and 5 years in 10	B	7	14.3	15	23.1
More than 7 years in 10	B/A	18	36.7	21	32.3
		1st Round		**3rd Round**	
Do you plan to do this next year?		**n**	**Percent**	**n**	**Percent**
Yes		51	94.4	66	90.4
No, I plan to do something different		3	5.6	3	4.1
If you plan to do something different, what is it?					
1st Round	**3rd Round**				
• Adjust stocking rate to grass stocks, but more intensively. • Put up internal fences to rotate and spell pastures if we have the money to do so • We just need rain to actually put some targets in place and carry out more spelling	• Full crop pasture management • Wait for rain • For some paddocks it will be the same, sometimes we have half the amount of cattle because you sell a few extra at times. Stocking rate and spelling.				

Advice land managers follow when making decisions about adjusting stocking rates?

Land managers were asked to rank from 1= most important to 13=least important whose advice they follow most when making decisions about adjusting stocking rates. A cross tabulation between 'advice land managers follow when adjusting stocking rates' and 'round of data collection' compared responses from the first and third rounds of data collection (see Table 61 and Table 62).

In the first round of data collection, 'other graziers' was ranked as the most followed advisor overall, by contrast 'family who are also graziers' was the highest ranked as most important advisor. This was followed by 'Other. Who?' which included land managers own experience, consultants, other successful graziers, grazing best practice and local council or authority that is not a NRM, then 'people from NQ Dry Tropics', see Table 61.

Table 61: Advice Burdekin grazing land managers follow when making decisions about stocking rates, ranked 1 most important to 13 least important – 1st Round Data Collection

Advisor	1st Round													
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Total**
Other graziers	9	8	5	3	1	0	0	0	0	0	0	0	0	**26**
Family who are also graziers	20	1	2	1	0		0	0	0	0	0	0	0	**24**
Other. Who?	15	2	5	0	0	0	0	0	0	0	0	1	0	**23**
People from NQ Dry Tropics	6	3	4	3	0	0	0	0	0	0	0	0	0	**16**
Extension officers. From where?	2	2	4	2	0	0	0	0	0	0	0	0	0	**10**
Researchers	2	3	3	1	0	0	1	0	0	0	0	0	0	**10**
People from government departments. Which departments?	3	3	2	0	0	0	0	0	0	0	0	0	1	**9**
Meat & Livestock Australia	1	1	2	2	0	1	0	0	0	0	0	0	0	**7**
Landcare	0	3	2	2	0	0	0	0	0	0	0	0	0	**7**
Private Agronomists	1	0	2	0	0	0	0	1	0	0	0	0	0	**4**
Non-farming family/friends	0	1	1	0	0	0	0	0	0	0	1	0	0	**3**
Agforce	0	0	1	0	0	0	0	0	1	0	0	0	0	**2**
QLD Farmers Federation	0	0	1	0	0	0	0	0	0	1	0	0	0	**2**

**Other. Who? (number of responses): their own experience (11); consultants e.g. Resource Consulting Services (4); trials/education programmes (1); other successful graziers (1); grazing best practice (1); local council/authority, not NRM (2)*
***Other Extension, from where?: DAF (5); Department of Natural Resources (2); CSIRO (1); NQDT (1)*
****Government Departments: DAF/DPI (5)*

In the third round, 'Other. Who?' was ranked as the most important advisor and included the land managers own experience, consultants, trials and education programmes, industry representatives and that advice was dependent on rainfall. 'Family who are also graziers was next most important, followed by 'other graziers' as the advisors graziers follow when making decisions about stocking rates, see Table 62.

Table 62: Advice Burdekin grazing land managers follow when making decisions about stocking rates, ranked 1 most important to 13 least important – 3rd Round Data Collection

Advisor	3rd Round													
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Total**
Other. Who?	30	5	0	2	0	1	0	0	0	0	1	0	1	**40**
Family who are also graziers	19	9	3	0	3	0	0	1	1	0	0	0	0	**36**
Other graziers	12	13	4	3	1	1	0	1	0	0	0	0	0	**35**
People from NQ Dry Tropics	6	8	7	3	3	1	0	2	0	1	0	0	0	**31**
Extension officers. From where?	4	1	2	4	2	1	0	0	1	0	2	1	0	**18**
People from government departments. Which departments?	0	5	4	0	0	0	0	0	1	1	1	4	1	**17**
Meat & Livestock Australia	1	1	4	0	0	2	2	3	1	0	1	0	0	**15**
Researchers	3	3	3	1	1	1	2	0	0	0	0	1	0	**15**
Private Agronomists	1	2	1	2	0	1	1	1	0	1	0	2	0	**12**
Landcare	0	1	3	2	1	1	1	0	1	0	1	1	0	**12**
Agforce	0	1	1	2	0	1	2	0	1	2	0	1	0	**11**
Non-farming family/friends	0	0	1	0	0	0	0	0	2	2	0	2	0	**7**
QLD Farmers Federation	0	0	0	1	1	0	0	1	0	1	0	1	2	**7**

**Other. Who? (number of responses): their own experience (16); consultants e.g. Resource Consulting Services (7); trials/education programmes (2); industry representatives (2); dependent on rainfall (1)*
***Other Extension, from where?: DAF (9); Northern Gulf Resources (2).*
****Government Departments: DAF (8)*

Attitudes and motivations associated with adjusting stock rates to paddock conditions (other than wet season spelling)

The next question asked participants how important a set of listed statements were to land managers when making decisions about adjusting stocking rates. The participants were asked to choose the importance of each statement on a scale of 1-strongly disagree to 7 strongly agree, with 4 being neutral.

The first set of statements considered influencers when making decisions about adjusting stocking rates. Burdekin graziers follow their chosen method for adjusting stocking rates because the graziers they respect most are using the same practice. There is a higher agreeance in third round data (M=6.07, SD=1.18) compared to first round data (M=5.63, SD=1.53). The data indicates that land managers decisions about adjusting stocking rates are also somewhat influenced by 'the people/organisations whose advice I follow most think I should do this' in both first (M=5.54, SD=1.94) and third round (M=5.36, SD=1.76) data. First and third round data indicates that graziers held a neutral stance on the statement 'other graziers having the technical knowledge to implement the current pasture spelling practices' (first round M=4.44, SD=2.02; third round M=4.22, SD=2.16), indicating that they were not sure of other land managers technical knowledge. Land managers disagreed that graziers could not afford the systems being used for adjust stocking rates (first round M=3.54, SD=2.25; third round M=3.82, SD=2.28) and they also did not agree that they were being forced to use the methods, see Table 63. An independent t-test produced a significant difference in the scores between rounds of data collection for the statement 'I only do this because I am forced to. What or who is forcing you?' The means score indicated a stronger dis-agreeance in the third round than in the first round of data collection.

Table 63: Burdekin grazier land manager attitudes and motivations associated with adjusting stocking rates

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
The graziers I respect most do this	54	5.63	1.53	73	6.07	1.18
The people/organisations whose advice I follow most think I should do this	54	5.54	1.94	73	5.36	1.76
Most graziers in this region would not have the technical knowledge to do this	54	4.44	2.02	73	4.22	2.16
Most graziers in this region would not be able to afford to do this	54	3.54	2.25	73	3.82	2.28
I only do this because I am forced to. Who/what is forcing you?*	54	3.13	2.66	73	2.16	1.97
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

The mean scores for 'I only do this because I am forced to' show disagreement with the statement, see Table 63. The anecdotal responses indicate that while no-one is forcing grazing land managers to adjust their stocking rates, in the first round of data collection they felt that they were forced to adjust their stocking rates by the drought, nutrition management, pasture condition, and by their management plans. In the third round of data they indicated that the force was coming from succession goals, knowledge that adjusting stocking rates is essential and from pressure from the government, see Table 64.

Table 64: Anecdotal comments from Burdekin land managers about who/what is forcing them to adjust stocking rates

1st Round	3rd Round
• Drought is a key influence • For our cows to calve each year they need to have a rising plan of nutrition through pregnancy and lactation. We achieve this through wet and dry lick supplement depending on animal age. These are only effective if you have a reasonable body of roughage to offset the supplement program • Keep pasture in good condition and keep cattle performing • Sustainability, pasture health • Yes management plan forces me to - I made the plan and I need to stick with it. And environment.	• Just the way we do it • Kids - next generation • Knowledge that it is essential • Too dry • Weather dependent and feel pressure from Govt.

The second set of statements ask the land manager to read the statement and respond how using their method for adjusting stocking rates measures when compared to other ways of managing stocking rates.

While all statements have high agreement (see Table 65) 'the best way to meet my own personal goals' and 'the best way to reduce business risk' are the most agreed with motivators for using the method to adjust stocking rates that the land manager is using. Grazing land managers agreed that 'controlling erosion' and 'maintaining good cash-flow' were also considered when thinking about the system for adjusting stocking rates or not during the wet season. While being time consuming or labour intensive were neutral to motivation to adjust stocking rates. An independent t-test produced no significant difference in scores for each statement.

Table 65: Compared to other ways of adjusting stocking rates, what motivates Burdekin grazier land managers to use the system that they use?

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
The best way to meet my own personal goals	54	6.31	1.08	73	6.01	1.11
The best way to reduce business risk	54	6.00	1.18	73	6.01	1.07
The most effective way of controlling erosion on my property	54	5.89	1.41	73	5.71	1.37
The best way to maintain good cash-flow	54	5.83	1.26	73	5.82	1.12
The least time-consuming (or labour intensive)	54	4.70	1.74	73	4.78	1.92
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

Has adjusting stock rates to paddock conditions practices (other than wet-season spelling) changed?

To establish whether there was a change in the way land managers adjust stocking rates between first and third round data collection, a multiple response cross-tabulation was performed using the land manager unique identification number to identify graziers in each round of data collection (1=Grazier First Round and 3=Same Grazier Third Round). However,

the number of graziers who completed the survey in both rounds was too small to draw conclusions from the analysis.

6.3.3.4 Stock management around waterways

Land managers were asked to answer a series of questions about stock management around waterways. The responses from the first round of data were compared to responses from the third round of data to identify any changes in stock management around waterways.

When asked if respondents managed stock around their waterways during the most recent wet season, the majority in both first and third round data collection selected that they did spell their paddocks in the most recent wet season.

When asked what practices land managers were using to manage stock around waterways, 31.5% of first round respondents selected that they prevent cattle from accessing some waterways at all times, by contrast in the third round, only 8.8% of respondents were using the practice (this change may be due to the extended drought in the area, or Table 66, may offer some alternative management practices). More land managers in third round (30.9%) were preventing access to some waterways during the wet season, when compared with first round (24.1%). Around the same amount of land managers in first round (18.5%) and third round (19.1%) were not preventing cattle from accessing water points. Nearly 12% in third round data collection were preventing cattle from accessing waterways in the wet season and less than 5% in both rounds of data collection prevented cattle from accessing waterways at all times. Grazing land managers have been using these practices to manage their land for between 1 and 30+ years. Most of the grazing land managers are planning to do the same practice in the next year. Those that are doing something different have listed fencing off areas or adding extra water troughs as their management plan, see Table 66.

Table 66: Burdekin land manager's practices for managing stock around waterways

	1st Round		3rd Round	
	n	**Percent**	**n**	**Percent**
How do you manage stock around waterways?				
I prevent cattle from accessing some waterways at all times	17	31.5	6	8.8
I prevent cattle from accessing some waterways during the wet season	13	24.1	21	30.9
I do not prevent cattle from accessing waterways	10	18.5	13	19.1
*Other. Please tell us what you do	9	16.7	17	25.0
I prevent cattle from accessing all waterways during the wet season	3	5.6	8	11.8
I prevent cattle from accessing all waterways at all times	2	3.7	3	4.4
	54	100	68	100
How long have you used this system to manage stock around waterways?	**n**	**Percent**	**n**	**Percent**
1-5 Years	10	19.2	12	18.2
6-10 Years	13	25.0	20	30.3
11-20 Years	20	38.5	22	33.3
21-25 years	2	3.8	1	1.5
26-30 Years	3	5.8	3	4.5
31 Years +	4	7.7	8	12.1
	52	100	66	100
Do you plan to do this next year?	**n**	**Percent**	**n**	**Percent**
Yes	51	94.4	66	97.1

If you plan to do something different, what is it?	
1st Round	**3rd Round**
Fence off more waterways	More fencing
put in extra trough and do internal fencing and this will give us five paddocks	Hoping to get grant for fencing, otherwise it will remain the same

Those that were doing something else were preventing cattle from accessing waterways some of the time, using bore water to manage cattle away from creeks and using a combination of practices to manage stock around their waterways, see Table 67.

Table 67: Anecdotal comments from Burdekin grazing land managers about other practices they are using to manage stock around waterways

1st Round	3rd Round
• Access to waterways some of the time • At present stock may have access to waterways for periods of about a week about 4 times a year, same as the rest of the landscape • Control when & how long cattle access the waterway, but not necessarily tied to the 'wet season' • Have bore and trough set up to encourage cattle away from creek • I control riparian as needed to maintain ground cover and stop erosion • No permanent water in creeks; No permanent water in waterways • Part of rotational strategies • We manage cattle access to waterways	• Careful Rotation and Fencing and maintenance of ground cover • Cattle access waterways for short graze periods no more than three times a year • Depending on saturation event • Encourage cattle to water troughs • I don't entirely prevent them but I strategically place watering points away from the waterways so they don't congregate in the area, not permanent waterways. Do try to spell those areas throughout the wet season, not entire season but part of it, I guess that would be a help • I use a combination. Some always, some never, some wet season spelling • In the wet season all waterways excluded and in the dry season some waterways are excluded • Management according to season; access on stable soils and riparian areas only; fencing off riparian areas for controlled grazing; • Most creeks are fenced off with access to trough. • Prevent cattle from accessing some water ways some of the time. • Prevent cattle from accessing waterways at various times • Rotate stock; too many waterways • Spell paddocks including waterways • We offer alternative troughs for the cattle to water from • We have fenced cattle out of some water courses • We prevent cattle accessing waterways as much as possible during the wet season

Advice land managers follow when making decisions about stock management around waterways?

Land managers were asked to rank from 1= most important to 13=least important whose advice they follow most when making decisions about stock management around waterways. A cross tabulation between ‘advice land managers follow when managing stock around waterways’ and ‘round of data collection’ compared responses from the first and third rounds of data collection (see Tables 68 and 69).

In the first round of data collection, ‘other graziers’ was ranked as the most followed advisor overall, by contrast ‘family who are also graziers’ was the highest ranked as most important advisor. This was followed by ‘Other. Who?’ which included land managers own experience, consultants, other successful graziers, grazing best practice and local council or authority that is not a NRM, then ‘people from NQ Dry Tropics’, see Table 68.

Table 68: Advice Burdekin grazing land managers follow when making decisions about managing stock around waterways, ranked 1 most important to 13 least important – 1st Round Data Collection

Advisor	1st Round													
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Total**
Other graziers	8	8	4	3	1	0	0	0	0	0	0	0	0	**24**
Other. Who?	15	2	4	1		0	0	0	0	0	0	0	1	**23**
Family who are also graziers	18	2	1	1	0	0	0	0	0	0	0	0	0	**22**
People from NQ Dry Tropics/TERRAIN	7	6	6	1	1	0	0	0	0	0	0	0	0	**21**
Researchers	3	3	4	1	0	1	0	0	0	0	0	0	0	**12**
Extension officers. From where?	2	2	3	3	0	1	0	0	0	0	0	0	0	**11**
Landcare	2	3	3	2	1	0	0	0	0	0	0	0	0	**11**
People from government departments. Which departments?	2	1	2	0	0	0	0		0	0	0	1	0	**6**
Meat & Livestock Australia	1	1	2	1	0	0	0	0	1	0	0	0	0	**6**
Private Agronomists	1	0	1	0	0	0	1	0	0	1	0	0	0	**4**
Non-farming family/friends	0	1	1	0	0	0			0	0	1	0	0	**3**
Agforce	0	0	1	0	0	0	1	0	0	0	0	0	0	**2**
QLD Farmers Federation	0	0	1	0	0	0	0	1	0	0	0	0	0	**2**

**Other. Who? (number of responses): their own experience (8); consultants e.g. Resource Consulting Services (5); trials/education programmes (1); other successful graziers (1); holistic management graziers/educators (1); grazing best practice (1); local council/authority, not NRM (1)*
***Other Extension, from where?: DAF (4); Department of Natural Resources (2); CSIRO (1); NQDT (1)*
****Government Departments: DAF/DPI (2)*

In the third round, 'family who are also graziers' were ranked both as the most important advisor overall and as the most important advisor, followed by 'other graziers'. 'Other. Who?' was ranked as the third most important advisor and included the land managers own experience, consultants, trials and education programmes and industry representatives, see Table 69.

Table 69: Advice Burdekin grazing land managers follow when making decisions about managing stock around waterways, ranked 1 most important to 13 least important – 3rd Round Data Collection

Advisor	3rd Round													
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Total**
Family who are also graziers	18	6	4	0	3	1	0	1	1	0	0	0	0	**34**
Other graziers	11	11	4	4	1	1	0	1	0	0	0	0	0	**33**
Other. Who?	25	3	0	0	0	0	0	0	0	0	1	0	1	**30**
People from NQ Dry Tropics/TERRAIN	6	8	6	4	1	1	2	0	2	0	0	0	0	**30**
Extension officers. From where?	3	3	2	3	2	1	0	1	0	1	1	1	0	**18**
People from government departments. Which departments?	0	3	6	0	0	0	1	0	0	1	1	3	2	**17**
Researchers	4	2	1	3	1	1	1	0	1	1	1	0	0	**16**
Meat & Livestock Australia	1	0	2	1	1		3	1	3	1	0	1	0	**14**
Agforce	0	1	1	3	1	2	0	1	0	1	0	2	0	**12**
Landcare	1	3	2	1	0	0	0	1	0	1	1	1	0	**11**
Private Agronomists	1	1	1	0	0	1	2	1	0	0	0	2	0	**9**
QLD Farmers Federation	0	0	0	0	1	1	1	0	0	1	1	1	1	**7**
Non-farming family/friends	0	0	1	0	0	0	0	0	1	1	0	2	1	**6**

**Other. Who? (number of responses): their own experience (15); consultants e.g. Resource Consulting Services (8); trials/education programmes (1); industry representatives (1)*
***Other Extension, from where?: DAF (7); credible environmental officers (1); NQDT (3); local industry representatives (1)*
****Government Departments: DAF (6)*

Attitudes and motivations associated with stock management around waterways

The next question asked participants how important a set of listed statements were to land managers when making decisions about managing stock around waterways. The participants were asked to choose the importance of each statement on a scale of 1-strongly disagree to 7 strongly agree, with 4 being neutral.

The first set of statements considered influencers when making decisions about adjusting stocking rates. Burdekin graziers follow their chosen method for managing stock around waterways because 'the people/organisations whose advice they follow most think they should do this'. There is a slightly lower agreeance in third round data (M=5.59, SD=2.03) compared to first round data (M=5.10, SD=1.87). The data indicates land managers decisions about managing stock around waterways are also somewhat influenced by 'the graziers they respect most think they should do it' in both first (M=5.17, SD=1.80) and third round (M=5.28, SD=1.55) data. First round data (M=4.26, SD=2.23) indicates that graziers held a neutral stance on the statement 'other graziers having the technical knowledge to implement current pasture spelling practices'. However, in third round data (M=3.85, SD=2.08) collection they somewhat disagreed with the statement, indicating they thought other land managers had the technical knowledge to manage stock around waterways. Land managers were unsure if graziers could not afford the systems being used for managing stock around waterways (first round M=4.09, SD=2.28; third round M=4.01, SD=2.12) and they did not agree that they were being forced to use the methods, see Table 70.

Table 70: Burdekin grazier land manager attitudes and motivations associated with stock management around waterways

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
The people/organisations whose advice I follow most think I should do this	54	5.59	2.03	68	5.10	1.87
The graziers I respect most think I should do this	54	5.17	1.80	68	5.28	1.55
Most graziers in this region would not have the technical knowledge to do this	54	4.26	2.23	68	3.85	2.08
Most graziers in this region would not be able to afford to do this	54	4.09	2.28	68	4.01	2.12
I only use this system to manage stock around waterways because I am forced to. Who/what is forcing you?*	54	3.48	2.64	68	2.38	2.02
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

An independent t-test highlighted a significant difference for 'I only do this because I am forced to. What or who is forcing you?' score for first round (M=3.48, SD=2.64) and third round (M=2.38, SD=2.02; t(120)=2.53, p=.01, two tailed). The magnitude of difference in the means (mean difference =1.10, 95% CI: .24 to 1.96) was small to moderate (eta squared =.05). The results show that while land managers indicated they are forced to manage stock around waterways, it had decreased in importance between first round and third round data collection, only .5% of the variance was explained by time between the data collection points. This may be due to land manager's lack of control of natural waterways, the number of waterways and the financial means to manage waterways. There was no significant difference between the other means across the two data collection periods.

While there were no anecdotal comments in the first round, the anecdotal comments from the third round of data indicate that the force was coming from excessive natural waters, financial burden and too many waterways to effectively manage, see Table 71.

Table 71: Anecdotal comments from Burdekin grazing land managers about who/what is forcing them to manage stock around waterways

1st Round	3rd Round
No comments	• Excessive natural waters • Finances not enough money for fencing • Financial • Knowledge that it is very beneficial to the environment • Too many waterways to effectively manage • Too expensive to fence off every creek

The second set of statements asked the land manager to read the statement and respond how using their method for managing stock around waterways measures when compared to other ways of managing stock around waterways.

While all statements have high agreement (see Table 72) 'the most effective way of controlling erosion on my property' and 'the best way to meet my personal goals' are the most agreed with motivators for using the method that the land manager is using to manage stock around waterways. Grazing land managers agreed that 'the best way to maintain good cash flow' and 'the best way to reduce business risk' were also considered when thinking about the system they use for managing stock around waterways, or not, during the wet season. Being time consuming or labour intensive were neutral to motivation to managing stock around waterways.

Table 72: Compared to other ways of managing stock around waterways, what motivates Burdekin grazier land managers to use the system that they use?

	1st Round			3rd Round		
	n	Mean	SD	n	Mean	SD
The most effective way of controlling erosion on my property	54	5.69	1.66	68	5.19	1.61
The best way to meet my own personal goals	54	5.65	1.39	68	5.43	1.30
The best way to maintain good cash-flow*	54	5.56	1.54	68	4.85	1.43
The best way to reduce business risk	54	5.54	1.51	68	5.13	1.38
The least time-consuming (or labour intensive)	54	4.54	1.89	68	4.53	1.75
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

An independent t-test highlighted a significant difference for 'the best way to maintain good cash flow' score for first round (M=5.56, SD=1.54) and third round (M=4.85, SD=1.43; t(120)=2.61, p=.01, two tailed). The magnitude of difference in the means (mean difference =.70, 95% CI: .17 to 1.24) was small to moderate (eta squared =.05). The results indicate that while land managers agreed the way they managed stock around waterways was the best way to maintain good cash flow, it had decreased in importance between first round and third round data collection, only 0.5% of the variance was explained by time between the data collection points. This may be due to land manager's lack of financial means to manage waterways or it may be associated with drought or other farming practices and warrants further investigation. There was no significant difference between the other means across the two data collection periods.

Has managing stock around waterway changed?

To establish whether there was a change in the way land managers manage stock around waterways between first and third round data collection, a multiple response cross-tabulation was performed using the land manager unique identification number to identify graziers in each

round of data collection (1=Grazier First Round and 3=Same Grazier Third Round). However, the number of graziers who completed the survey in both rounds was too small to draw conclusions from the analysis.

Other innovative practices for managing stock around waterways

Land managers were asked if they used any other innovative practices to manage stock around waterways. Sixty three percent selected 'yes' that they thought they were using innovative practices in first round data collection and 33.9% selected 'yes' in the third round. However, when matching responses to the ABCD Framework, the practices used meet conventional to best management practice expectations. A list of anecdotal comments from land managers describing the practices are included in Appendix 5. Table 73 gives examples of practices being used, matched to the ABCD Framework.

Table 73: Other innovative practices - anecdotal comments from Wet Tropics land managers, coded (see Appendix 5 for examples)

Do you use any other innovative practices to manage nitrogen and/or run-off?	**1st Round**		**3rd Round**	
	n	**Percent**	**n**	**Percent**
Yes	22	40.7	38	52.1
No	15	27.8	20	27.4
Other comments	17	31.5	15	20.5
Total	**54**	**100**	**73**	**100**

Coded Responses to Innovative Practices (see examples in Appendix 5)	**ABCD Framework**	**1st Round**		**3rd Round**	
		n	**Percent**	**n**	**Percent**
Contouring banks	C, B	2	12.5	1	7.1
Erosion Prevention Project	B, A	6	37.5	4	28.6
Riparian Zone Management	C	1	6.25	0	0.0
Maximum Pasture Management	B	2	12.5	3	21.4
Gully Management	B	2	12.5	2	14.3
Grazing Management Practices	B	3	18.75	3	21.4
Fencing	C, B	0	0.00	1	7.1
Nothing, stopped by GOV regulations	D	0	0.00	1	7.1
	Total	**149**	**100**	**55**	**100**

6.3.3.5 Perceptions of Causes and Pressure on Water Quality

Land managers were asked to agree (7) or disagree (1) with a statement about how nutrient loss impacts water quality in local streams, rivers and waterways. They could also select that they did not know or were unsure how local streams, rivers and waterways were impacted (8) or neutral (4).

A means analysis shows that grazing land managers are taking measures to reduce soil loss from their property to improve land conditions and they somewhat agree that soil loss from their property negatively impacts their pasture production and grazing land condition.

Land managers also recognise that sediment loss from their property is having an impact on water quality in local streams, rivers and waterways, see Table 78. An independent t-test produced no significant difference in scores for each statement, highlighting that there has been no change in land managers perceptions about soil loss between the first round and third round of data collection.

Table 74: Means analysis of Burdekin grazing land managers to the statement about how soil loss impacts water quality from the Burdekin region

	1st Round			3rd Round		
	n	Mean	SD	n	Mean	SD
I am taking measures to reduce soil loss from my property and improve land conditions	53	6.42	0.77	73	6.49	0.84
Soil loss from my property negatively impacts my pasture production and grazing land condition	53	5.72	1.70	73	5.45	2.15
Sediment loss from my property has no impact on water quality in local streams, rivers & waterways	53	3.64	2.09	73	4.03	2.32
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

When asked what Burdekin grazing land managers thought were the top two causes of poor water quality in local streams, rivers and waterways, they responded that the top cause in first round data collection was erosion/sediment (15.2%) and vegetation/weed management (15.2%) and the second top cause was poor land management (22.2%). In the third round of data collection, erosion/sediment (12.9%) and lack of rain or irregular water flow (12.9%) were identified as the top cause of poor water quality. By contrast, 12.9% identified as not having poor water quality in their local streams, rivers and waterways as the first cause. The second top cause identified in third round data collection was erosion/sediment (17.9%), see Appendix 10 for anecdotal land manager comments, which were coded into themes contained in Table 75.

Table 75: Burdekin grazing land managers two top causes of poor water quality in local streams, rivers and water ways – Burdekin

	1st Round				3rd Round			
	Cause 1		Cause 2		Cause 1		Cause 2	
	n	Percent	n	Percent	n	Percent	n	Percent
Erosion/sediment	7	15.2	4	11.1	9	12.9	7	17.9
Vegetation/weed management	7	15.2	4	11.1	7	10.0	5	12.8
Lack of rain or irregular water flow	6	13.0	2	5.6	9	12.9	2	5.1
No poor water quality	4	8.7	0	0.0	9	12.9	0	0.0
Poor soil	3	8.7	0	0.0	0	0.0	1	2.6
Drought	3	6.5	4	11.1	3	4.3	1	2.6
No ground cover	3	6.5	2	5.6	5	7.1	3	7.7
Chemicals/contamination	2	4.3	3	8.3	2	2.9	1	2.6
Mining	2	4.3	1	2.8	3	4.3	1	2.6
Pollution and or rubbish	2	4.3	1	2.8	0	0.0	1	2.6
Poor grazing practices	8	4.3	0	0.0	5	7.1	5	12.8
Heavy rainfall or extreme weather	1	2.2	4	11.1	5	7.1	2	5.1
Feral animals	1	2.2	0	0.0	2	2.9	2	5.1
Main roads	1	2.2	0	0.0	1	1.4	1	2.6
Excessive use of fire	1	2.2	0	0.0	0	0.0	0	0.0
Poor land management	0	0.0	8	22.2	3	4.3	4	10.3
Don't Know/Other	1	0.0	1	2.8	4	5.7	0	0.0
Poor cane farming practices	0	0.0	1	2.8	1	1.4	0	0.0
Government/Legislation/Policy	0	0.0	1	2.8	0	0.0	0	0.0
Urban development	0	0.0	0	0.0	1	1.4	2	5.1
Run-off	0	0.0	0	0.0	1	1.4	1	2.6
Total	**52**	**100**	**36**	**100**	**70**	**100**	**39**	**100**

Next Burdekin grazing land managers were asked to strongly agree (7) or strongly disagree (1) with a statement about the role that grazing plays in the declining health of the Great Barrier Reef (GBR). Land managers could also select that they did not know or were unsure (8) or neutral (4) about what role grazing plays in the declining health of the GBR.

A means analysis indicates that in both first round and third round data collection, land managers held a neutral stance towards the statement "the grazing industry plays almost no role in the declining health of the Great Barrier Reef".

Table 76: Means analysis of Burdekin grazing land manager statement about the role cane growing plays in the declining health of the Great Barrier Reef

	1st Round			3rd Round		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**
The grazing industry plays almost no role in the declining health of the Great Barrier Reef	53	4.15	1.96	73	4.75	2.09
*Note: 1=strongly disagree, 7=strongly agree, *=significant at 5% level*						

A frequency analysis of the same data (see Figure 7) shows less agreeance with the statement in third round data collection than in first round data collection. This may indicate a change in attitude towards the role that the grazing industry plays in the declining health of the Great Barrier Reef by Burdekin cane farmers i.e. that graziers may play some role in the declining health of the GBR.

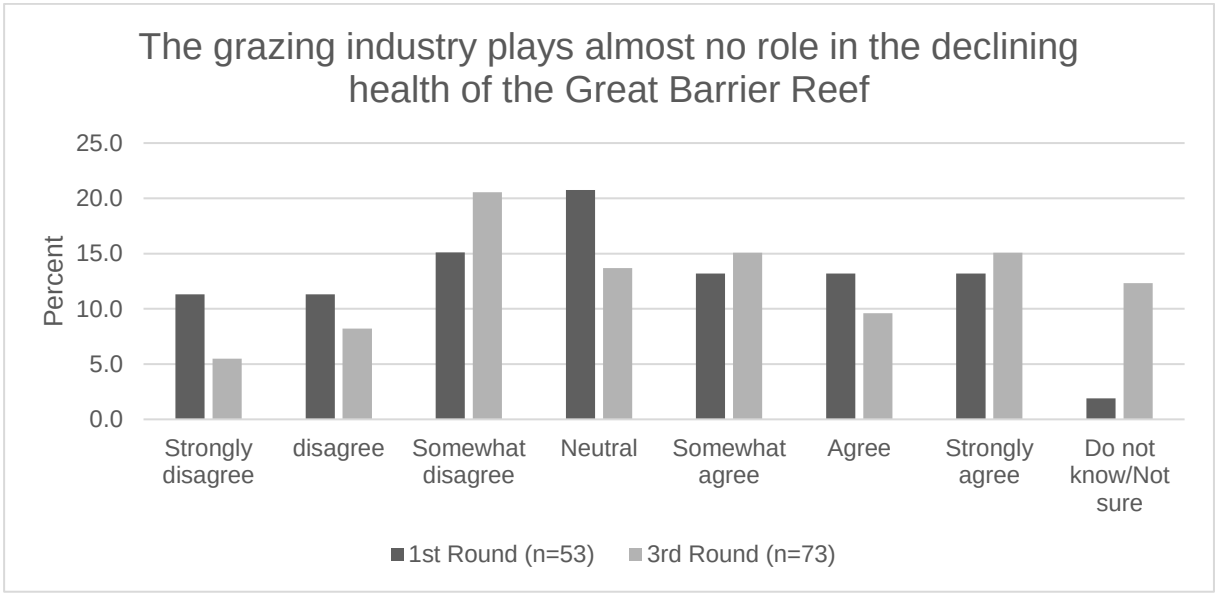

Figure 7: Responses from Burdekin grazing land managers about the role grazing industry plays in the declining health of the Great Barrier Reef

Burdekin grazing land managers were asked to write comments about what they thought the two top pressures were on the GBR. Land manager responses were coded into themes, a full list of anecdotal comments can be found in Appendix 11. In the first round of data collection Burdekin graziers' listed chemical run-off (18.9%) as the main pressure on the GBR. The second top pressure was listed as land clearing/erosion/lack of ground cover (14.6%). In the third round of data collection urban development/pollution (21.7%) was listed as the top pressure and more so as the second top pressure (22.4%) on the GBR. Other pressures

include climate change, sediment, recreation and commercial fishing and natural processes. These results support earlier findings (Farr et al., 2017d, p. 77) that grazing land managers tend to shift the blame related to water quality and the health of the Great Barrier Reef rather than consider their own practices as adding pressure to the GBR.

Table 77: Burdekin grazing land managers - two top pressures on the health of the Great Barrier Reef

	1st Round				3rd Round			
	Pressure 1		Pressure 2		Pressure 1		Pressure 2	
	n	Percent	n	Percent	n	Percent	n	Percent
Chemical Run-off	10	**18.9**	4	9.8	2	2.9	11	19.0
Climate Change/Global Warming	9	17.0	1	2.4	9	13.0	2	3.4
Urban Development/Pollution	8	15.1	5	12.2	15	**21.7**	13	**22.4**
Sediment	5	9.4	1	2.4	10	14.5	4	6.9
Don't know/Unsure	3	5.7	3	7.3	6	8.7	0	0.0
Natural Process	3	5.7	3	7.3	2	2.9	5	8.6
Coral Bleaching/Crown of Thorns	2	3.8	3	7.3	3	4.3	1	1.7
Inconsistent messages/knowledge	2	3.8	1	2.4	1	1.4	1	1.7
Tourism	2	3.8	0	0.0	0	0.0	2	3.4
Weather Events	2	3.8	0	0.0	6	8.7	0	0.0
Land clearing/Erosion/Lack of ground cover	1	1.9	6	**14.6**	1	1.4	2	3.4
Government	1	1.9	0	0.0	0	0.0	0	0.0
Mining	1	1.9	0	0.0	3	4.3	5	8.6
Other farming (not cane or grazing)	1	1.9	3	7.3	0	0.0	2	3.4
Pests/Weeds	1	1.9	2	4.9	0	0.0	0	0.0
Shipping/Boating Damage	1	1.9	1	2.4	1	1.4	2	3.4
United Nations/Greens Groups	1	1.9	2	4.9	0	0.0	0	0.0
Australian Defence Force	0	0.0	0	0.0	1	1.4	1	1.7
Nutrient Run-off	0	0.0	0	0.0	0	0.0	1	1.7
Other Run-off	0	0.0	1	2.4	2	2.9	2	3.4
Greenies/Do gooders	0	0.0	0	0.0	2	2.9	1	1.7
Sustainability	0	0.0	1	2.4	1	1.4	0	0.0
Recreational/Commercial Fishing	0	0.0	4	9.8	4	5.8	1	1.7
Lack of financial support	0	0	0	0.0	0	0	1	1.7
Minority Land Holders	0	0	0	0.0	0	0	1	1.7
Total	53	100	41	100	69	100	58	100

6.3.1.8 Grazing land managers results summary

This section has reported on results from questions related to nutrient and run-off management practices in the dry tropics region of Queensland, Australia.

The results from the analysis confirm that grazing land managers in the Burdekin region goals for their property are to create a sustainable and viable business to pass on to future generations while improving pastures, groundcover and reducing weeds to increase productivity. When making decisions to reach their goals, Burdekin grazing land managers were primarily driven by maintaining the physical and mental health of their family. While spending time with family, maintaining good relationships with other farmers and keeping in contact with family and friends was also important, maintaining family traditions and heritage was of neutral importance to decision making in the third round of data collection compared to the first round.

Financially, grazing land manager decisions were influenced by minimising risk and maximising profits as well as keeping a steady cash flow. Keeping farm costs low and reducing debt were less important to decision making. Land managers indicated that 'being able to make their own decisions about their farm/property was the most important factor when making decisions about what to do on the farm or property. Leaving the farm in better condition, improving water supplies and minimising sediment run-off were all equally important to decision making. Helping to safeguard native plants and animals and helping to safeguard the GBR both increased in importance when making decisions about what to do on the farm or property.

The data shows grazing land managers were spelling paddocks during the wet season and that they were following the advice of family who are also graziers, their own experience, consultants, and staff from the Department of Agriculture and Fisheries as well as other farmers when making decisions about paddock spelling. While there was a slight decrease in importance in third round, grazing land managers are implementing these practices because the people or organisations whose advice they follow most, thinks that they should be implementing these practices and also because the graziers they respect most are also implementing the pasture practices, which increased in importance over the duration of the study. This change reflects initial findings that found that graziers don't make decisions in isolation (see Farr et al., 2017d). Graziers were using their pasture spelling practice because it was the best way to meet their own personal goals when managing pasture spelling.

We could not measure if there was a change in pasture spelling practices because not enough land managers completed the survey in the first round and then again in the second round of data collection.

The majority of grazing land manager respondents identified they were using other innovative practices to manage stock around waterways. When matching responses to the ABCD Framework, it was identified the practices being used met conventional to best management practice expectations.

While grazing land managers were taking action to reduce soil loss from their property, they were less certain that the soil loss had a negative impact on their pasture production and

grazing land condition by the third round of the study. Overall, recognition that sediment loss has an impact on water quality moved from dis-agreeance to a neutral stance, but there was no significant difference in grazing land managers perception over the duration of the study.

In the beginning of the survey period, land managers identified problems with water quality to be caused by erosion and sediment, vegetation and weed management, and lack of rain or irregular water flow in local streams, rivers, and waterways. By the end of the study, erosion was equally identified with lack of rain or irregular water flow as a cause or poor water quality in local streams, rivers, and waterways. By contrast, some grazing land managers highlighted in the third round of data collection that they did not think that there was poor water quality in local streams, rivers, and waterways. Others highlighted poor grazing practices and poor land management as the second top cause of poor water quality in local streams, rivers, and waterways.

Graziers in the Dry Tropics region held a neutral stance about grazing playing a role in the declining health of the Great Barrier Reef. They identified the top pressures as being chemical run-off, climate change or global warming and urban development at the beginning of the study. In the final year of the study grazing land managers identified the pressure on the health of the Great Barrier Reef to be mainly caused by urban development and pollution followed by chemical run-off and climate change and global warming.

6.3.4 Round 3 Data Structural Equation Modelling Results

The estimates reported in Table 78 describe the impact of various predictors on the consequents related to water quality behaviours, i.e. run-off behaviour and fertilizer application behaviour. Results from the Wet Tropics region suggest that financial goals ($\beta = -0.453$, $p < 0.05$), technical knowledge ($\beta = -0.219$, $p < 0.05$) and labour extensiveness ($\beta = -0.262$, $p < 0.05$) are significantly linked with Run-off behaviour. The results related to fertilizer application behaviour suggest that social goals are strongly linked with desired fertilizer application behaviour ($\beta = 0.279$, $p < 0.05$). Similarly, the results from the Burdekin region suggest that favourable fertilizer application behaviour can be shaped if focus is put on financial goals ($\beta = 0.759$, $p < 0.05$) as well as environmental goals ($\beta = 0.725$, $p < 0.05$). It can thus be suggested that financial viability and environmental cause can have a positive influence on shaping industry-specific standards in fertilizer application behaviour. Results linked with run-off behaviours show that financial goals ($\beta = -0.435$, $p < 0.05$), environmental goals ($\beta = -0.143$, $p < 0.05$), technical knowledge ($\beta = -0.175$, $p < 0.05$) and being forced to adopt run-off behaviours ($\beta = -0.155$, $p < 0.05$) can be relied on to shape desired run-off behaviours in the Burdekin region.

The results reported in Table 79 highlight how various theoretical constructs are linked with individual goals. It is evident that in the Wet Tropics region lifestyle goals strongly affect subjective norms for fertilizer application behaviour ($\beta = 0.311$, $p < 0.05$). However, for run-off behaviours in the same region lifestyle goals are only linked with the attitude towards behaviour ($\beta = 0.600$, $p < 0.05$). Results from the Burdekin region show social goals are linked with attitude towards fertilizer application behaviour ($\beta = 0.340$, $p < 0.05$) as well as Run-off behaviour ($\beta = 0.358$, $p < 0.05$).

Table 78: Estimates of Water Quality Behaviours

Predictors (X)	**Consequent**									Model Fit
Run-Off Behaviour – Cane Growers Wet Tropics region (n=105)										
	Run-off Behaviour			Technical Knowledge			Labour Extensive			
	Coefficient	SE	P	Coefficient	SE	P	Coefficient	SE	P	Nagelkarke R^2
Financial Goals	-0.453	0.224	0.043	-0.106	0.154	0.945	0.108	0.128	0.399	0.164
Technical Knowledge	-0.219	0.109	0.045	-	-	-	-	-	-	
Labour Extensive	-0.262	0.143	0.067							
Fertilizer Application Behaviour - Cane Growers Wet Tropics region (n=105)										
	Fertilizer Application Behaviour									
	Coefficient	SE	P	Coefficient	SE	P	Coefficient	SE	P	Nagelkarke R^2
Social Goals	0.279	0.112	0.014	-	-	-	-	-	-	0.108
Fertilizer Application Behaviour – Cane Growers Burdekin Region (n=33)										
	Fertilizer Application Behaviour									
	Coefficient	SE	P	Coefficient	SE	P	Coefficient	SE	P	Nagelkarke R^2
Financial Goals	0.759	0.526	0.048	-	-	-	-	-	-	0.169
Environmental Goals – Great Barrier Reef	0.725	0.503	0.040	-	-	-	-	-	-	0.191
Run-off Behaviour – Cane Growers Combined Burdekin and Wet Tropics (n=148)										
Financial Goals – cost	-0.435	0.207	.011	-	-	-	-	-	-	0.153
Environmental Goals – leaving farm in better condition	-0.143	0.213	.047	-	-	-	-	-	-	
Run-off Technical Knowledge	-0.175	0.095	.023	-	-	-	-	-	-	
Forced to adopt Run-off Behaviour	-0.155	0.101	.0019	-	-	-	-	-	-	

Table 79: Relationship of Goals and TPB Constructs

Region	Behaviour	Predictor (X)	Consequent	Estimate	P	Status
Wet Tropics	Fertilizer Application Behaviour	Life Style Goals	Subjective Norms	0.311	0.022	Supported
			Attitude towards Behaviour	0.160	0.346	Not Supported
		Financial Goals	Subjective Norms	-0.121	0.446	Not Supported
			Attitude towards Behaviour	0.222	0.112	Not Supported
		Social Goals	Subjective Norms	0.274	0.083	Not Supported
			Attitude towards Behaviour	0.045	0.831	Not Supported
		Environmental Goals	Subjective Norms	-0.169	0.446	Not Supported
			Attitude towards Behaviour	-0.142	0.478	Not Supported
	Run-off Behaviour	Life Style Goals	Subjective Norms	0.071	0.640	Not Supported
			Attitude towards Behaviour	0.600	0.000	Supported
		Financial Goals	Subjective Norms	0.046	0.798	Not Supported
			Attitude towards Behaviour	-0.089	0.578	Not Supported
		Social Goals	Subjective Norms	0.231	0.137	Not Supported
			Attitude towards Behaviour	-0.088	0.500	Not Supported
		Environmental Goals	Subjective Norms	-0.051	0.796	Not Supported
			Attitude towards behaviour	-0.301	0.078	Not Supported
Burdekin	Fertilizer Application Behaviour	Life Style Goals	Subjective Norms	0.191	0.477	Not Supported
			Attitude towards Behaviour	0.258	0.122	Not Supported
		Financial Goals	Subjective Norms	-0.117	0.626	Not Supported
			Attitude towards Behaviour	-0.038	0.838	Not Supported
		Social Goals	Subjective Norms	-0.151	0.573	Not Supported
			Attitude towards Behaviour	0.340	0.036	Supported
		Environmental Goals	Subjective Norms	0.341	0.251	Not Supported
			Attitude towards Behaviour	-0.155	0.394	Not Supported
	Run-off Behaviour	Life Style Goals	Subjective Norms	0.055	0.832	Not Supported
			Attitude towards Behaviour	0.395	0.007	Supported
		Financial Goals	Subjective Norms	-0.015	0.927	Not Supported
			Attitude towards Behaviour	-0.025	0.875	Not Supported
		Social Goals	Subjective Norms	-0.322	0.232	Not Supported
			Attitude towards Behaviour	0.358	0.050	Supported
		Environmental Goals	Subjective Norms	0.329	0.296	Not Supported
			Attitude towards Behaviour	-0.160	0.228	Not Supported

Additionally, we ran several models to explain the structure of the four goals (i.e. lifestyle goals, financial goals, social goals and environmental goals) and their relationship with the constructs of the theory of planned behaviour (reported through Figure 8 to Figure 11). The PLS SEM approach was used to assess these relationships. The key advantages of PLS-SEM are that it is more flexible to sample sizes and less sensitive to violation of multivariate data assumptions (for instance, the normality of data) and provides equally reliable results without compromising on the rigor and external validity (Faizan, Mostafa, Marko, M., & Kisang, 2018).

From the estimated model of fertilizer application behaviour in the Burdekin region (Figure 8) it is evident that lifestyle goals are primarily driven by maintaining family traditions and heritage (λ = 0.740), followed by the desire to spend face-to-face time with family and friends (λ = 0.720), maintaining physical and mental health of family (λ = 0.638) and maintaining good relationships with other farmers / graziers in the local area (λ = 0.536). Financial goals were found to be strongly affected by the intent of maximizing farm profits (λ = 0.852) followed by the desire of minimizing the risk of very high costs or very low income (λ = 0.670) and servicing debt (λ = 0.643). Social goals were mostly affected by the desire of sharing new ideas with others (λ = 0.860) followed by learning about and testing new ways of doing things on farm/property (λ = 0.789) and having efforts recognized by the wider community (λ = 0.562). Finally, the environmental goals in the region, and for the behaviour, were primarily motivated by the desire of helping to safeguard local waterways (λ = 0.846) followed by leaving the land/farm in better condition than it was when the land manager first started managing it (λ = 0.783), minimizing sediment run-off and/or nutrient losses (λ = 0.705) and helping to safeguard local waterways (λ = 0.544).

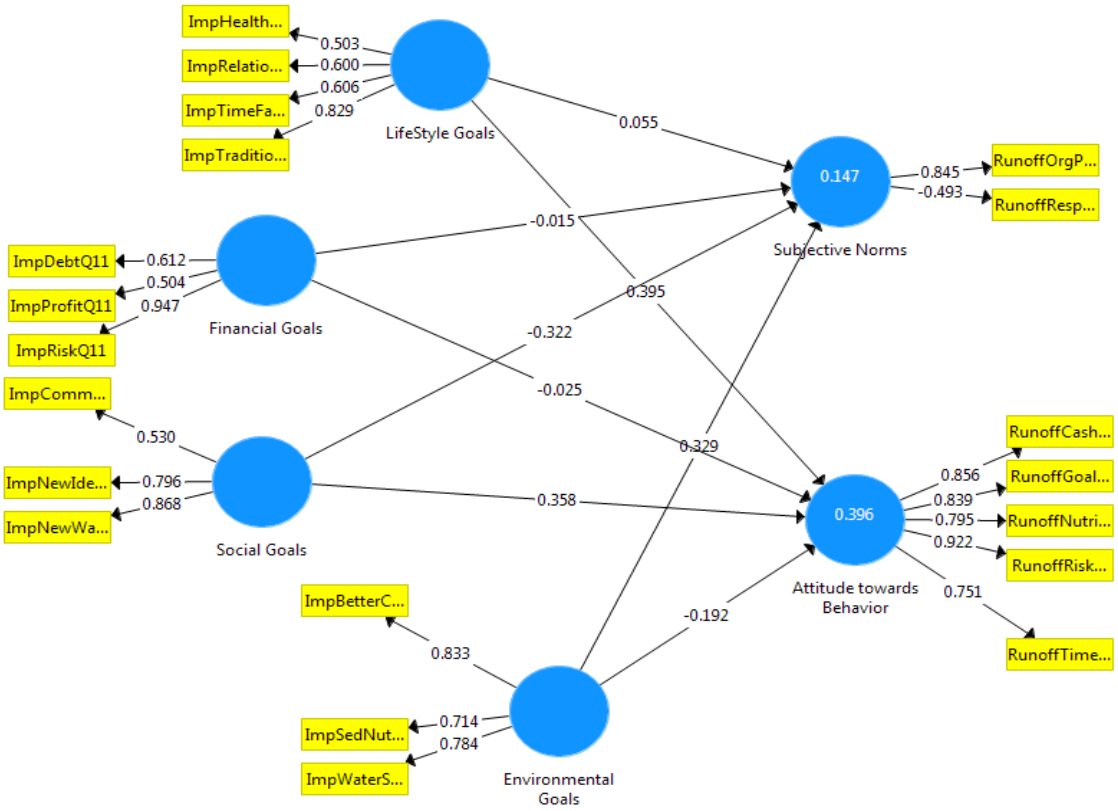

Figure 8: Run-off Behaviour - Cane Growers, Burdekin

From the estimated model of run-off behaviour in the Wet Tropics region (Figure 9), it is evident lifestyle, financial goals and social goals were key factors associated with the constructs of the TPB. Results reveal that lifestyle goals were primarily driven by the desire of maintaining good relationships with other farmers/graziers in the local area (λ = 0.848) followed by maintaining physical and mental health of family (λ = 0.837), keeping in contact with family and friends in other ways (λ = 0.719) and maintaining family traditions and heritage (λ = 0.69). Financial goals were motivated primarily by profit expectations (λ = 0.943) followed by desire of keeping a stable (steady) cash-flow (λ = 0.904), keeping farm costs low (λ = 0.851) and minimizing the risk of very high costs or very low income (λ = 0.826). Finally the social goals were found to be primarily driven by the desire of learning about and testing new ways of doing things on the farm/property (λ = 0.856) followed by sharing new ideas with others (λ = 0.820), having time to pursue hobbies (λ = 0.583) and having efforts recognized by the wider community (λ = 0.582).

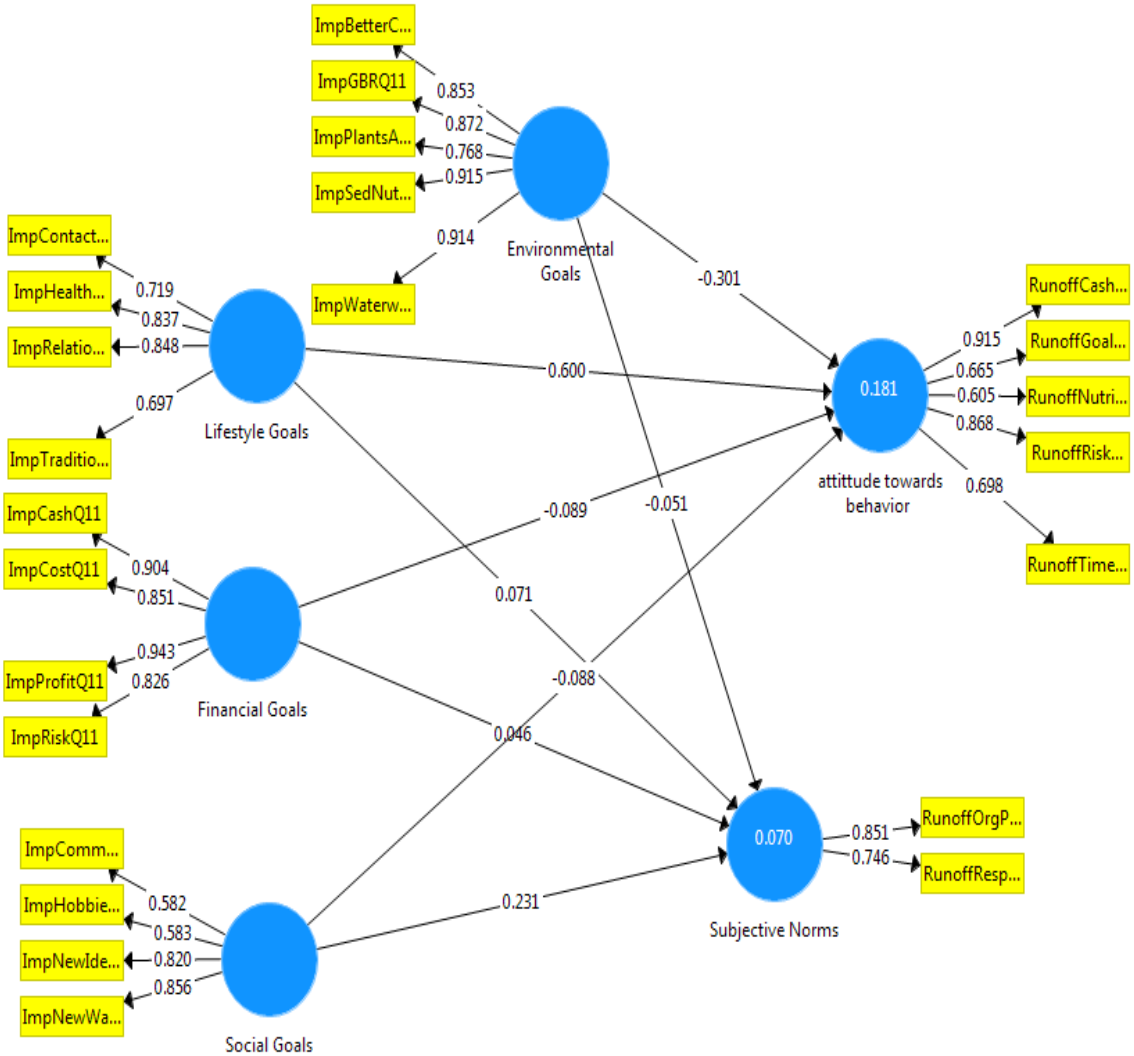

Figure 9: Run-off Behaviour - Cane Growers, Wet Tropics

The test for fertilizer application behaviour in the Burdekin (Figure 10) and the Wet Tropics (Figure 11) regions shows how well each element of the goals is linked with its first order construct.

From the estimated model of fertiliser application in the Burdekin region (Figure 10) it is evident that lifestyle goals are strongly affected by traditions (λ = 0.740) followed by time spent on farm (λ = 0.720), importance of health (λ = 0.638) and importance of relationships with other farmers (λ = 0.536). Similarly, financial goals are primarily driven by profit motives (λ = 0.852), followed by risk factors (λ = 0.670) and debt considerations (λ = 0.643). Social goals on the other hand are primarily driven by farmers' goals of sharing new ideas with others (λ = 0.860) followed by learning about and testing new ways of doing things on the farm (λ = 0.789) and the desire of having efforts recognized by wider community (λ = 0.562). Finally, environmental goals are primarily driven by the desire of maintaining and improving water supplies and storages (λ = 0.846) followed by the objective of leaving the property/farm in better condition (λ = 0.783), minimizing sediment run-off and/or nutrient losses (λ = 0.705) and helping to safeguard local waterways (λ = 0.544).

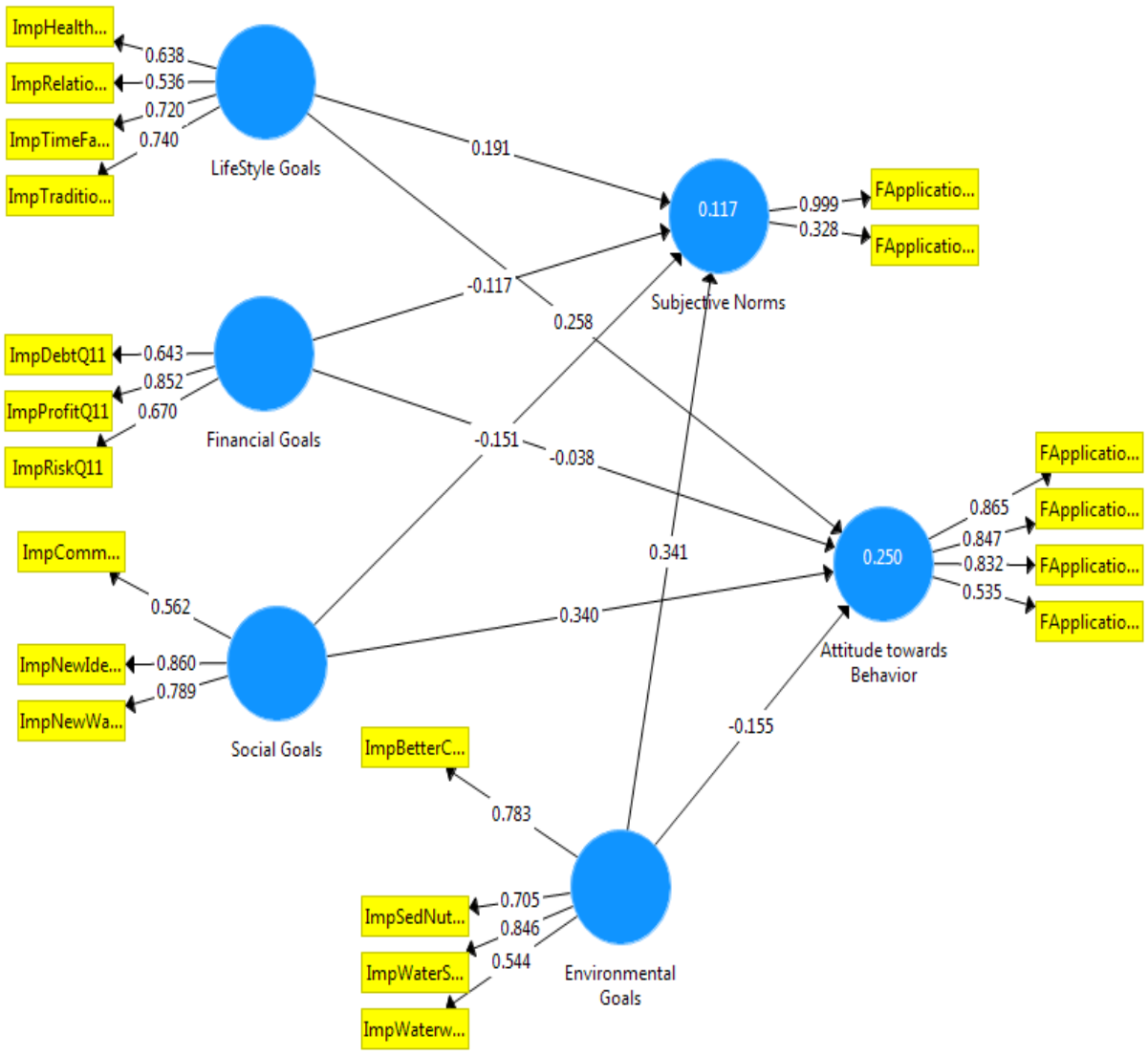

Figure 10: Fertilizer Application Behaviour - Cane Growers, Burdekin

From the estimated model of fertilizer application behaviour in the Wet Tropics region (Figure 11) it is evident that lifestyle goals are strongly affected by the desire of maintaining good relations with other farmers/graziers in the local area (λ = 0.905) followed by maintaining the physical and mental health of family (λ = 0.756), keeping in contact with family and friends in other ways (λ = 0.713) and by maintaining family traditions and heritage (λ = 0.717). Similarly, financial goals were primarily driven by profit (λ = 0.929) followed by the desire of keeping a stable (steady) cash-flow (λ = 0.902), minimizing the risk of very high costs or very low income (λ = 0.888) and keeping farm costs low (λ = 0.827). Finally the third important set of goals in the Wet Tropics region, and for fetilizer application behavior was social goals, which were primarily driven by the desire to share new ideas with others (λ = 0.794) followed by learning about and testing new ways of doing things on farm / property (λ = 0.738), having time to pursue hobbies (λ = 0.684) and the desire of having efforts recognized by the wider community (λ = 0.683).

Estimated models of Run-off behaviour in Burdekin (Figure 1) and Wet Tropics (Figure 3) region show the estimates of elements for each goal associated with the constructs of the theory of planned behaviour.

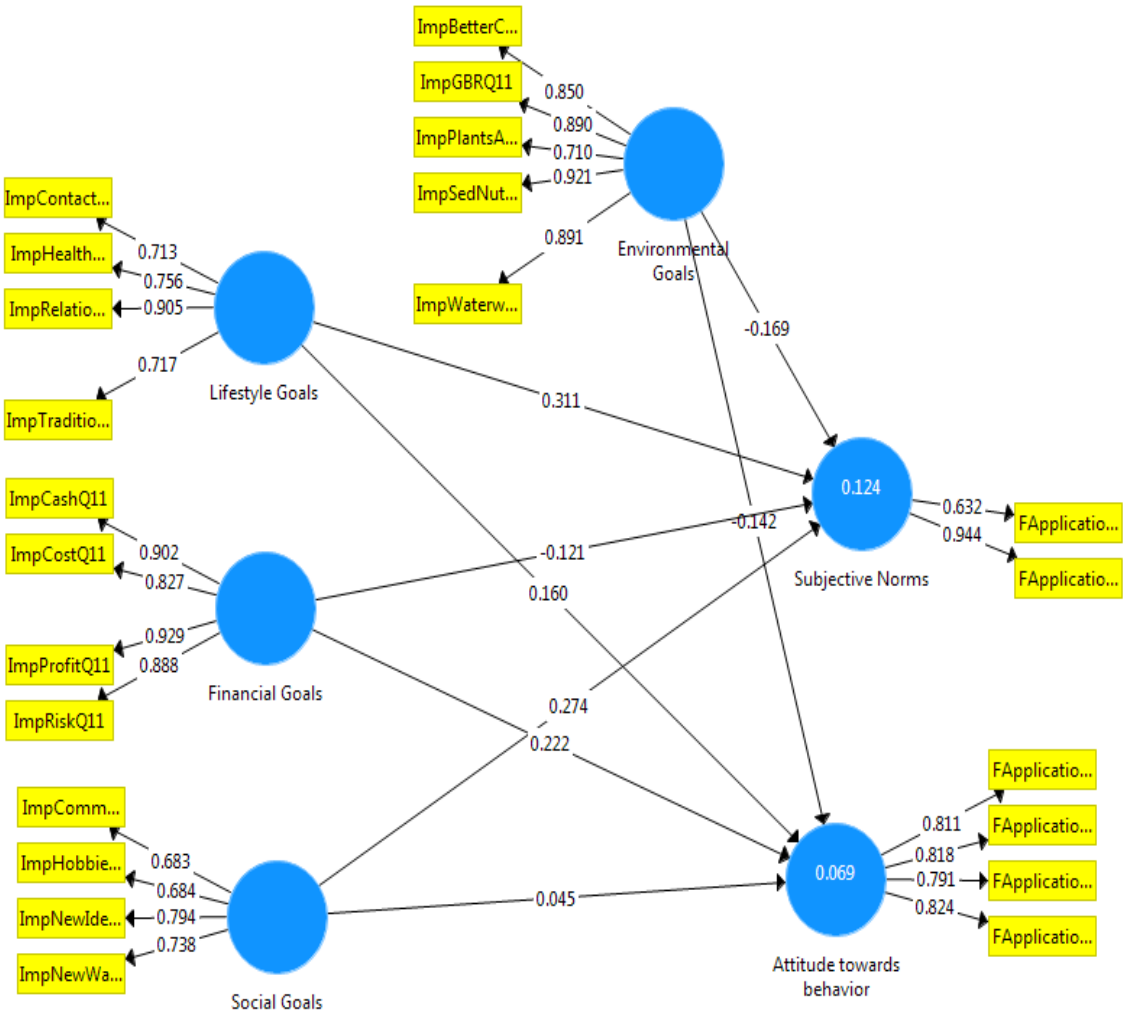

Figure 11: Fertilizer Application Behaviour: Cane Growers, Wet Tropics

It is important to note the high influence that networks have on land manager decisions, as they may identify barrier to practice change. The findings support previous recommendations for a land manager network analysis to ensure that information gatekeepers and opinion leaders influence future water quality communication strategies (see Hay & Eagle, 2018).

6.3.5 Recommendations

A full list of recommendations from the third round of data collection can be found in Section 8.6.

6.3.6 Limitations

See 5.3 **Structural Equation Modelling**.

7.0 RESPONSE TO RESEARCH OBJECTIVES

Consistent with a plea to determine 'what works, for whom, in what circumstances and for how long' (Marteau et al., 2011, p. 264; Taylor, Pollard, Rocks, & Angus, 2012), this project uses insights from the science of social marketing and behaviour change (see Eagle et al., 2016) to implement (and test the efficacy of) changes to the marketing and engagement strategy associated with programmes designed to be rolled out under the Reef 2050 Plan. It aimed to change key behaviours to improve WQ. The following section addresses the main objectives set prior to the beginning of the project.

7.1 Research Objective 1

Identify intrinsic and extrinsic motivations (motivations), value-orientations (values), norms, 'habits' (particularly relating to NRM), social networks and communication protocols of different segments of land managers (particularly graziers and cane growers) in regions where WQ improvement programmes have recently been, or will soon be, rolled out.

Land managers were asked about motivations, satisfaction, and reasons why they do things for three different practices, calculating fertiliser rates, irrigation practices and handling run-off for cane growers and spelling paddocks, stocking rates and managing stock around waterways for graziers.

An individual's values and stereotypes such as balance of work and lifestyle values, economic, environmental and conservation values, self-transcendent, prosocial, altruistic and biospheric values' self-enhancement (i.e. hedonic, egoistic) values and biospheric concern were found to be significant determinants of pro-environmental behaviour. Social predictors are likely to see culture, tradition, and self-identity as significant positive determinants of pro- environmental behaviour and information predictors include consulting practical advice, scientific advice, and technical information. Financial benefits and training opportunities can also make pro-environmental behaviour more attractive. Therefore, the research aimed to identify the reasons why land managers were doing specific agricultural practices or not doing them, what motivates them in these decisions, and whose advice is most important to land managers (for a more in depth discussion on pro-environmental behaviour and its determinants, see (Farr et al., 2017a).

The table below identifies motivations, values, habits, social networks and communications protocols activated when making decisions about what to do on the land managers farm or property. It also identifies norms surrounding calculating fertiliser rates for cane farmers and adjusting stocking rates for graziers. The percentage shows how much the land managers agreed with the factor when making decisions on their farm or property. These factors (and others contained in this report and previously published interim reports, which can be found here https://nesptropical.edu.au/index.php/round-2-projects/project-2-1-3/) may be considered when communicating with land managers about decisions being made about water quality management.

Table 80: Factors activated when making decisions about what to do on the land managers farm or property

Importance of factors when making decisions (Extremely Important or Essential)			
	Wet Tropics Cane Growers	**Burdekin Cane Growers**	**Burdekin Graziers**
Intrinsic Motivation	Being able to make your own decisions (69%)	Being able to make your own decisions (72%)	Being able to make your own decisions (61%)
Extrinsic Motivation	Leaving the land/farm in better condition (69%)	Leaving the land/farm in better condition (67%)	Leaving the land/farm in better condition (74%)
Value-orientation (values)	Physical & mental health of family (71.5%)	Physical & mental health of family (58%)	Physical & mental health of family (68%)
Norms	The farmers I respect most use the practice I use to calculate fertiliser rates (60%)	The farmers I respect most use the practice I use to calculate fertiliser rates (61%)	The farmers I respect most use the practice I use to adjust stocking rates (69%)
Habits	Minimising sediment run-off and/or nutrient losses (66%)	Minimising sediment run-off and/or nutrient losses (67%)	Minimising sediment run-off and/or nutrient losses (57%)
Social Networks	Good relations with other Farmers / graziers (38%)	Good relations with other Farmers / graziers (28%)	Good relations with other Farmers / graziers (18%)
Communication Protocols	Keeping in contact with family & friends in other ways (34%)	Keeping in contact with family & friends in other ways (26%)	Keeping in contact with family & friends in other ways (32%)

7.2 Research Objectives 2 & 5

Research Objective 2

Assess reactions of land managers to complexities of language, message framing and communication channels ('messaging') used in the programmes, perceptions of barriers to and potential enablers of adoption of these programmes, perceptions of 'threats' to personal freedoms and 'trust' in the programme.

Research Objective 5

Work with those who are implementing new programmes to use insights from (1) – (4) above, to suggest and, where appropriate, implement 'live' alterations to marketing and engagement strategies, i.e. undertake adaptive alterations to those strategies to encourage participation amongst those likely to be disinclined to participate.

While the reactions of land managers to complexities of language, message framing and messaging was not directly assessed, the materials supporting the programmes themselves were assessed through a documentary analysis and the results disseminated to the NRMs, researchers and other interested stakeholders, particularly in sugar cane growing regions to enact a change in the level of readability of those materials, and in turn, the land manager's understanding of the project objectives.

Insights from the project's document readability analysis extended an understanding that communication materials need to be delivered in a way that can be read by the target audience.

These were incorporated by the Social Marketing@Griffith team for the Queensland Government's RP167C Sandy Creek Project: On farm change for water quality improvement. Analytical techniques were shared with the Social Marketing@Griffith researchers and improvements were made to communications materials. The RP167C project team reported enhanced readability was achieved in the Mackay Area Productivity Services (MAPS) communications (e.g. web sites, newsletters), by Farmacist, and in a report card from both the State of Queensland and Healthy Rivers to Reef Partnership. The study involved both engaged (those who actively collect water samples) and disengaged (those who are not actively pursuing growing practice change) land managers.

Invitation to present a workshop with Reef Catchments (Mackay) – Better Connected Training Workshop for agricultural extension July 2019

Note: The following overview has been extracted from the Reef Catchments project report with permission.

A workshop funded by the Queensland Government Reef Water Quality Program was held for those interested in communicating regularly with industry members and extension officers. The workshop was attended by extension officers, agricultural trainees, agronomists, government, local council and communications staff. Twenty one people registered to attend this event, with 14 people actually attending on the day (absences were due to illness and conflicting demands of the cane crushing season).

The full day's training covered a range of topics designed to increase extension and project officer confidence when connecting, communicating and building relations with landholders. The workshop covered a range of topics including understanding your audience, talking face-to-face, developing relationships and trust, dealing with negative/hostile stakeholders (positive deviants), identifying key influencers in participant's agricultural community, talking with larger groups and improving written communications.

Feedback from the Better Connected workshop was very positive (see feedback statement below) with 92.8% of attendees rated the workshop 'excellent' or 'good' (57% excellent and 36% good), with 7% rating it 'fair'.

> *"As someone new to the industry, I gained a good insight of different types of relationships and issues present and how to deal with them. Very informative, engaging and worthwhile."*

As part of the feedback process, participants were asked to identify the communications issues they commonly face in their extension roles. *For extension officers and those working in the sustainable agriculture/ NRM / Reef space* communication and connection challenges / issues were identified as:

- Lack of engagement from growers
- Reaching the growers / importance of channels – what is the best way to effectively reach the right people?; Reaching reticent growers – distrust
- Debate about agreed best practice e.g. regenerative ag vs precision ag
- Communicating to landholders, industry, general public, government… does it all need to be tailored?; Push back on regulations
- Speaking the farmers language
- Reef regulations – trying to help them to comply but being considered 'pushing' government 'orders'
- Afraid to say the wrong thing
- Presenting ideas / methods when they are disagreed with or unwanted
- Mixed messages
- Identifying the influencers – how do we do this?
- Building relationships and trust
- Can be difficult meaningfully contacting landholders who are out on the land – hard to know who already knows whom
- Lack of consensus from within industry
- Distance
- Starting lines of communication

As part of the feedback process, participants were asked to identify the key points they would take from the training – what jumped out?

- Importance of setting the tone in grower interactions – avoiding patronising them
- Awareness of SMOG indicator (readability indicator for written material)
- Trying to drill down to what landholder drivers are
- Understanding the influencer network
- Awareness of networks mong landholders and within geographic locations
- Interesting survey results – what farmers think and find important
- Biases/ beliefs – remember we are all different
- Learning how to share stories and motivations to connect
- Self-examination re: beliefs and how to overcome bias when dealing with farmers
- Communicating with large groups
- Conflict management / resistance
- Social network analysis x 2
- The fact that there is commercial / practical value in developing good relationships. This is not just a warm and fuzzy area, but key to program success
- Importance of ensuring written material is simple and at the right level for the audience
- Knowing who to focus on building relationships with through social mapping
- Strategies to communicate with growers
- Social influence and the innovation model

7.3 Research Objectives 3 & 4

Research Objective 3
Examine similarities and differences in (1) and (2) between the land managers who have (do), and have not (do not), chosen (choose) to participate in the programmes.

Research Objective 4
Identify mismatches between the extrinsic incentives and marketing messages of evaluated programmes and the motivations, values, norms, habits and communication protocols of both participating and non-participating land managers.

Research objective 3 & 4 not met: the project was unable to engage land managers who have not chosen to participate in the programmes as data from these individuals was not collected by the two NRM organisations, both of which advised that they were unable to establish a system whereby data could be obtained from this group.

Innovators / Positive Deviants
The project engaged in face-to-face conversations with stakeholders at different stages of the project who shared some of their concerns about not being recognised as innovators and/or environmental stewards, but rather as negative or disengaged land managers. As a result, we recommend and encourage support for those land managers who have changed practice but who are seen by their peers as 'going against the norm' (described in the literature as 'positive deviants' (Pant & Hambly, 2009)).

Positive deviants need to be considered given the strength of comments from both cane growers and graziers. Survey comments indicate that 'farmers I respect' (i.e. strong social norms as part of farmer identity) is a stronger influence than wider community factors, and that sharing new ideas is important (see the discussion of diffusion of innovation in Section 2.1 of the literature review, particularly the issues of compatibility, trialability and observability (Eagle et al., 2016b, p. 14)).

'Positive deviants' experiencing success are meeting their personal goals and expected outcomes of a particular practice. Meeting personal goals and expected outcomes are beliefs that are highlighted as important in the survey responses. Perceived control was also highlighted as important. Therefore, efforts to promote best management practice clearly and convincingly should demonstrate the ecological benefits, such as improving the environment and enhancing land managers ability to participate in ecological conservation activities to meet the perceived control behaviour. This suggests opportunities for extension officers to facilitate group 'social learning' with land managers, to share ideas and to learn from and support each other (Hermans, Klerkx, & Roep, 2015) as part of strategies for 'persuasion by discussion' (Scott, 2012, p. 64) and collective action (Blackstock, Ingram, Burton, Brown, & Slee, 2010), (excerpt from Farr et al., 2016).

Better Connected
Best management practice programmes largely ignore 'positive deviants' seeing them as disengaged. Disengaged or negative stakeholders choose not to engage or they actively oppose information because they believe that it is either unnecessary or intrusive or they may

not believe there is a problem in the first place (Trotter, 2015). When comparing responses from land managers and extension officers, it was clear that extension was underestimating the importance of safeguarding the surrounding environment to land managers (Hay & Eagle, 2018). When asked how important it was to safeguard the Great Barrier Reef when making decisions about what to do on their property, 59% of land managers said it was extremely important. By contrast, only 11% of extension officers thought this would be important to land managers when making decisions (Hay & Eagle, 2018). To change the level of trust for the land manager, stakeholders (especially extension officers) need to develop relationships.

Developing relationships and trust takes insight. Insight is the capacity to gain a deep understanding of others (landholders) worlds, as it exists for them. Insight comes from observations of people's realities (for example farm processes, family traditions, financial influence and norms), these observations trigger our beliefs about those realities, these triggered beliefs inform our judgement and our judgement affects how we make sense of what we are observing (adapted from Sanova, 2017). Biases and beliefs filter the information we receive and can distort our interpretation of what we observe.

External beliefs are mostly unconscious, and they can become outdated especially when not exposed to different ideas, cultures and rituals. Internal beliefs are those you have decided that are true, they come from things like your upbringing and your past experiences – they can be energizing or they can be limiting (Sanova, 2017).

The results of our study indicate that extension officer's may have filtered the information they received about land managers using their biases and beliefs, which distorted their interpretation of what they had observed of the land manager's decision influencers. Misunderstanding the importance of decision influencers may have changed the way messages were being sent and received (Hay & Eagle, 2018, p. 8), which may have significantly affected the level of trust of messages about water quality and how land managers process them.

When working with science, extension officer's belief systems are upgraded in line with research findings. If land managers are not keeping up then there becomes a disconnect in beliefs and biases, which causes a barrier to communication. When communicating with land managers, extension officers need to know their own biases and acknowledge them. Becoming aware of one's biases allows us to be aware of other people's biases. Knowing the disconnect between one's biases is fundamental to establishing intentional communication with land managers about best management WQ practices.

7.4 Research Objective 5

Research Objective 5

Work with those who are implementing new programmes to use insights from (1) – (4) above, to suggest and, where appropriate, implement 'live' alterations to marketing and engagement strategies, i.e. undertake adaptive alterations to those strategies to encourage participation amongst those likely to be disinclined to participate.

Alteration/improvement of a marketing strategy for one of the many WQ improvement programmes scheduled for rollout in 2017

A document readability analysis was completed on three water quality programmes in the Wet Tropics and Burdekin regions. The results have shown all three programmes to be written at a similar level well above the recommended reading level of grade / year 9 (Carbone & Zoellner, 2012; Kemp & Eagle, 2008). The documents associated with the Reef Programme (Burdekin), with a SMOG score of 13, were slightly more readable than documents associated with the Reef Trust Tender (Wet Tropics) (SMOG score of 17) or the Reef Programme (Burdekin) (SMOG score of 18). As a result, stakeholders involved in water quality management strategies, altered and improved programme material that was rolled out in 2017 (see Section 4.0 and Hay & Eagle (2016b) for more results from the readability study).

While stakeholders involved in the project altered or improved how they delivered their marketing strategy for water quality programmes, the many 'competing', and, at times, 'conflicting', water quality activities (see Section 3.0 Confounding Factors) that have been underway in both regions makes it difficult to separate out any one programme's effects from heightened awareness of effective communications, and issues such as readability in written communication. However, there are good examples from water quality project teams who have altered or improved their communications. Stakeholders and Project Managers supplied the following summaries of how the research had influenced communications for their programs as follows:

NQ Dry Tropics

> "The NQ Dry Tropics "Connecting Cane Farmers to Their Local Wetlands" project has been successfully trialling effective methods to increase sugarcane farmer adoption of farm management practices to achieve reef water quality outcomes and improve the ecological function of wetlands. The project created an engagement strategy based on learnings from a literature review and a social study of barriers and benefits of practice change. This strategy was updated annually based on a social monitoring, evaluation and project adaptation framework. As a result, 13 of the 14 participants are now trialling practice changes on their farms and the project team have a greater understanding of what extension, education, engagement, and communication tools work best to increase the benefits and decrease the barriers.
>
> The NESP 2.1.3 and 3.1.3 projects played an important role in the successful delivery of this project. The NESP project team reviewed the literature review, social study questions, project fact sheets, information publications, and media releases, providing useful input and insights for improvements. Their support helped us to improve the readability of our communication products to ensure they were appropriate for the target audience. Evaluations of these communication products showed that they were well received and understood by the cane farmers and increased their understanding and awareness of the subject matter (e.g. water quality issues for local wetlands and the Great Barrier Reef)."
>
> *Laura Dunstan, NQ Dry Tropics, Program Manager, Waterways, Wetlands and Coasts*

Terrain NRM

"Terrain NRM is involved in a number of projects that aim to support farmers in making practice change to improve water quality running off their farms. Given the subject matter, many of the supporting communications products tend to be scientific or technical in nature, which can make their readability challenging. The analysis provided to us by the NESP {2.1.3 and 3.1.3] team gave us reassurance that we were pitching our communications effectively at our target audience. In addition to giving us insights into how previous communications products could have been improved, they also helped inform the development of current materials by evaluating their readability and providing ideas and suggestions on how to refine them further."

Elaine Seager, Project Communications Leader, Terrain NRM

Behaviour Innovation

"Behaviour Innovation (BI) is a company that specialises in the design, delivery and evaluation of population-level behaviour change programs. Project Cane Changer is BI's flagship project and has been successful at increasing sugarcane growers' adoption of Smartcane BMP, a program with strong links to water quality and environmental benefits. BI has implemented behavioural skills training with extension officers and agronomists as part of Cane to Creek and Project Uplift to improve the on-the-ground skillset of extension staff.

The NESP 2.1.3 and 3.1.3 projects have provided a useful complement to the body of work BI is currently undertaking. The underlying concepts of the NESP projects are to understand the attitudes, behaviours, and barriers that landholders might have in terms of how they engage with practice change and environmental initiatives (e.g., water quality improvement). Both NESP projects have provided insights which are not only relevant to the approach of Cane Changer but have informed other projects in the region that aim to improve water quality and the health of the Great Barrier Reef."

Dr John Pickering, Cane Changer Project Manager, Chief Behavioural Scientist at Behaviour Innovation

The collaborative approach between the NESP TWQ Hub Project 2.1.3 team, NRMs, project managers and others had a positive effect on behaviour change. The collaboration allowed stakeholders to access the appropriate communication tools to implement them to improve water quality projects.

7.5 Research Objective 6

Research Objective 6

Assess the efficacy of these interventions, determining if they result in changed behaviours that are likely to generate more significant improvements in WQ than would otherwise occur.

Overall, there are positive indications that the water quality projects within the Wet Tropics and Burdekin regions are generating significant improvements in water quality as evidenced by comments from respondents to the survey and from feedback from project stakeholders.

Results to date show that:

- farmers' behaviour towards fertilizer application following the industry standards, depends on elements of lifestyle ('maintaining good relationships, with family, friends and other farmers and maintaining family traditions'), social goals ('learning about and testing new things, sharing new ideas and making my own decisions'), and environmental goals through subjective norms ('farmers I respect most do this').
- When handling run-off, the practice of using recycle pits was influenced by several motivational factors through attitude towards behaviour ('least time consuming and reduce business risk') and subjective norms ('farmers I respect do this').
- However, results for the use of recycle pits negatively mediated the impact, highlighting that although farmers recognise using recycle pits as the desired run-off practice, it may have been too time consuming and too risky for the business to adopt. These findings may explain the poor uptake of desired practices for improved water quality.

8.0 RECOMMENDATIONS AND CONCLUSION

8.1 Recommendations

The following recommendations have been drawn from each of the interim reports, which can be found at the Reef and Rainforest Research Centre website https://www.rrrc.org.au/nesp-twq-publications/

8.2 Recommendations Based on the Literature Review (Eagle et al., 2016b)

There is a need to:

- Ensure all communication, by whatever means, sends consistent messages irrespective of source, and channelling communication through trusted sources.
- Develop strategies for minimising the impact of competing and conflicting messages.
- Ensure that all persuasive communications are integrated in terms of key messages.
- Monitor media coverage and respond to inaccurate messages and develop proactive media relationships.
- Incorporate social media strategies as part of an integrated communication strategy that centres on the information channels and platforms used and preferred by land managers. Review communication strategies, adding social media where appropriate, recognising that this is likely to be most popular with younger land managers.
- Recognise the overall diversity of information sources and preferences.
- Incorporate long-term relationship management strategies based on customer relationship management and business to business marketing concepts.

8.3 Recommendations Based on the Documentary Analysis of Marketing Communications Material and subsequent Communications Best Practice Guide (Hay & Eagle, 2016b, 2019)

The analysis has provided relevant material that should be considered when writing marketing material for water quality programs and it has improved the understanding of the communication components. However it is limited in its scope to provide users with guidelines to produce quality communication material at the recommended reading level.

It is recommended that further research be completed to produce guidelines, templates and readability assessment tools and message framing guidelines to support the fine tuning of existing materials and the rollout of future communication material. During the analysis, it became evident that there were limitations to the materials content imposed by various government guidelines, which impacts heavily on readability. Therefore, it is important that the outcomes of this analysis be used in discussions to inform stakeholders beyond the regional natural resource management groups and others who supply the current programmes to land managers.

It is recommended that the Best Practice Guide for the development and modification of programme communication material (Reference) be developed into a series of communication workshops/webinars and/or an app/web based platform to accommodate numeracy and literacy levels of the target audience. It was noted in feedback that the document was too long and would not be useful. However, when presented to the Regional NRM Communication and Engagement Officers Network workshop as a guide to writing marketing communications, the attendees were excited that the guide could help them achieve the expectations of agricultural marketing material to inform behaviour change in water quality management.

As noted in Hay and Eagle (2016), the choice of images used as part of communication has significant impact on engagement. The link between imagery and communications framing has been noted (Geise and Baden, 2015) but under-researched in the environmental context (Hansen and Machin, 2013). It is suggested that the visual images that accompany news items may increase misconceptions about the true nature of an issue (Ryu et al., 2013; Walters et al., 2016). Further research should be carried out on the effects of visual imagery in the agri-environmental context.

It is recommended that the following principles of design be followed:

- Ensure that the content provided is the most up to date and necessary information.
- The document is organised in a way that encourages all of the information be consumed.
- That the credibility of the spokesperson be closely aligned with the message that is being distributed.
- That text, layout and colour are used to meet the WCAG 2.0 level of contrast to a AA or AAA standard.
- Visual imagery used must usefully add to the content.
- When including graphs and charts the Queensland Treasury guidelines will be used http://www.qgso.qld.gov.au/about-statistics/presentation/presenting-stat-infographs.pdf
- To find necessary and appropriate behaviour change solutions to water quality challenges, it is important to develop ways of communicating the need for effective 'buy in'. Improving the way projects communicate and get buy in from producers will ensure greater project uptake, associated results and lasting behaviour change.

8.4 Recommendations Based on First Round Descriptive Data Analysis Wet Tropics and the Burdekin (Farr et al., 2017b, 2017c; Farr et al., 2017d)

This preliminary analysis of the first round of data within the Wet Tropics and NQ Dry Tropics area revealed no 'unexpected findings' that run contrary to previous studies as outlined in our 2016 literature review (Eagle, Hay, & Farr, 2016). The responses from both cane growers and graziers indicate that there is a reluctance to accept that their actions impact negatively on the water quality of the Great Barrier Reef. Survey results show that cane growers were reluctant to accept that nutrient loss from their property also has an impact on water quality in local streams, rivers and waterways. Graziers, however, were more critical about their activities and the role that sediment plays in reducing water quality. The results indicate that both groups,

for each sector, have some tendency to shift blame to the other sectors (e.g. tourism, industry, government, other farmers, shipping and fishing), and to see issues of water quality as due to feral pigs in national parks and rainforest, soil run-off, river bank erosion, and erosion from bare fallow and roads, residential or industrial activity as well as due to weather patterns and climate change.

The recommendations that follow outline strategies that can be used to fine-tune existing landholder interactions. Further explanation of the recommendations can be found in Farr et al., (2016, pp. 53-64):

- There is a need to 'sell the science' to gain acceptance of the cause-effect relationship between farming practice and water quality. NRM groups should work with environmental science specialists to change views on the impact of farming practice on water quality.
- There is a potential to extend the key role of extension officers in potentially influencing increased uptake of BMP practices. There is a need to recognise the key role of extension officers and determine what professional development support might be beneficial in continuing to build trust and engagement with land managers.
- It is crucial to support innovation by celebrating success and sharing ideas. Land managers should see their expertise is valued and their voices heard.
- Facilitate sharing of ideas and practices.
- Build on the role of farmers whose views are respected as information gatekeepers / disseminators / role models.
- There is a need to ensure all communication, by whatever means, sends consistent messages irrespective of source, and channelling communication through trusted sources. Developing strategies for minimising the impact of competing and conflicting messages.
- Ensure that all persuasive communications are integrated in terms of key messages.
- Monitor media coverage and respond to inaccurate messages and develop proactive media relationships.
- Incorporate social media strategies as part of an integrated communication strategy that centres on the information channels and platforms used and preferred by land managers. Review communication strategies, adding social media where appropriate, recognising that this is likely to be most popular with younger land managers. Need to recognise the overall diversity of information sources and preferences.
- Incorporate long-term relationship management strategies based on customer relationship management and business to business marketing concepts.
- Utilise Social Network Analysis to identify:
    - key information gatekeepers / opinion leaders who may help or hinder information dissemination and innovation uptake, and recognise social relationships based on cultural / kinship factors.
    - where individual extension officers may fit into various networks
- Recognise land manager diversity but use typology principles to develop material and communication approaches to support extension officers in their interactions with specific subsets of land managers.

8.5 Recommendations Based on Second Round Data: Views from Extension Officers (Hay & Eagle, 2018)

The key role of extension officers in interactions with Australian land mangers has been recognized (see, for example, Ampt, Cross, Ross, & Howie, 2015; Vanclay, 2004). The challenge now is to support extension officers at a regional level in their interactions, particularly in difficult relationships with land managers who hold entrenched views regarding the best practice for managing their own land. The following recommendations are made to assist extension officers in their interactions with land managers.

Decision Making Factors

- Use social network analysis to identify information gatekeepers and opinion leaders.

The data indicates that extension officers may be underestimating the importance of decision influencers, which can affect the way messages are communicated and hence influence behaviour change.

Given the evidence that decisions are not generally made by one single individual and that the views of 'farmers I respect' are important, we believe that there is value in considering the use of Social Network Analysis (SNA). It is recommended that extension officers are trained in social network analysis and that the analysis be applied to cane farmers and graziers in the cane growing and grazing regions where there is the potential for identifiable individuals to play a key role, positive or negative, in information dissemination. It is important that this training is delivered through a consciously planned and facilitated delivery program rather than a self-enrol, self-managed delivery.

SNA is a set of techniques used to analyse the social and informational contacts between individuals with graphical representation ('sociograms') that use dots or circles to represent individuals and lines to represent connections between them (Dempwolf & Lyles, 2012). The following SNA is an example of a cane farming family located in the North Queensland region.

The value of SNA in the agri-environment context will lie in analysing the flow of information and discussions, and in particular in identifying the extent of influence of key information gatekeepers and opinion leaders who may have either power or influence over the adoption of innovations. It overcomes the limitations of analysis based only on geographic proximity by analysing social relationships that may be based on kinship or other factors. Advanced analysis can identify the strength of ties or connections between individuals (Prell, Hubacek, & Reed, 2009), see a discussion of SNA in Farr et al., (2017b, p. 89).

The sociogram, which contains data provided to the researchers by a cane grower in the Wet Tropics region of their own network (who has not had regular, recent official contact with extension officers), shows that all of the individuals are connected in this network. In this instance, the network maps shows both family and heritage ties, but may also show geographic proximity as well. The cane farmer (1) is connected to eleven people in Group 1, but also to the second cousin (13) who is connected to six people in Group 3. The cane farmer (1) is also connected to Group 2 via another second cousin (20), who is connected to eleven people. There is an indirect (weak) connection between second cousin (13) in Group 3 and the second

cousin (20) in Group 2 via the uncle (18). While the second cousins (13 & 20) might know each other they do not influence each other, but rather they both play a role in influencing the uncle (20). The cane farmer (1), second cousin (13), second cousin (20) and the uncle (18) may be identified in this farming family as the influencers. Therefore, it is important to identify the key influencers in any social network, both as potential disseminators of information or potential 'blockers' of practice change.

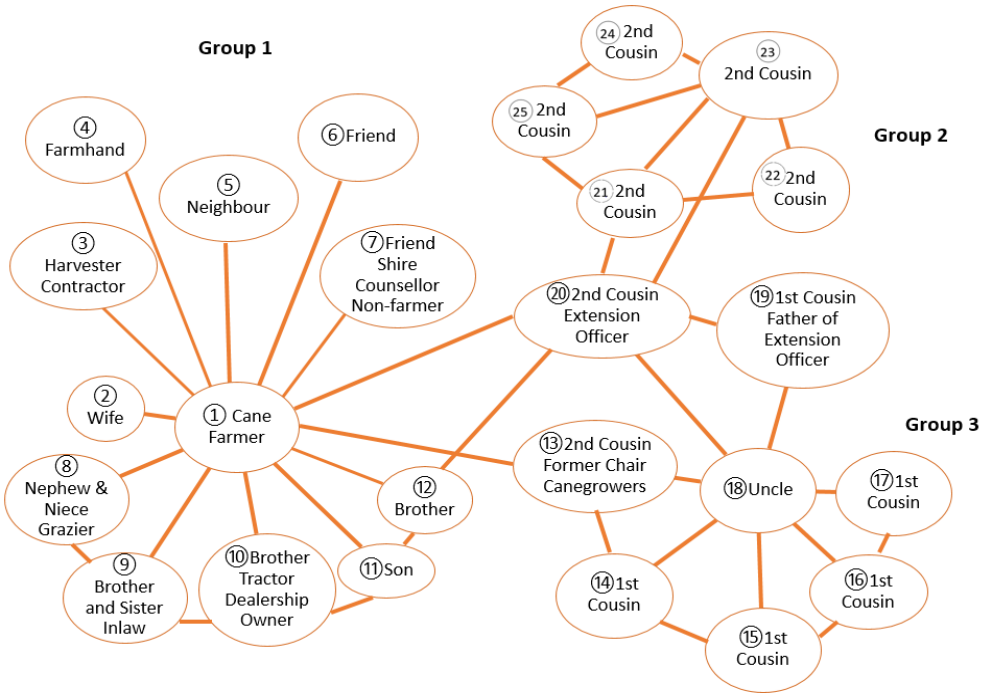

Figure 12: Social Network of a North Queensland Cane Farmer

Grants and Funding

The findings identify that an extension officer's perception of the success or failure of an application to a grant or funding may become a barrier for land managers to apply for funding. Early adopters (Hay, 2018, pp. 109-112) have larger numbers of social contacts, which influence the rate of adoption because of their role in those networks (Dowd et al., 2014). However, ideas will only be taken up if there is a favourable attitude towards them, which occurs when "others [extension officers] who he or she [land managers] have cause to trust are considering it or have already adopted it" (Scott, 2012, p. 69). Thus, key influencers (including extension officers) may act as a significant barrier to uptake of innovations (see the discussion of diffusion of innovation in Eagle et al., 2016b, p. 15). It may also be useful for extension officers to map networks for the land managers with whom they interact and to consider their own roles within these networks.

- Recognise the key role of extension officers and determine what professional development support might be beneficial in continuing to build trust and engagement with land managers.

There is a contrast in the findings where extension officers believe they are cognisant of land managers beliefs and land managers believe that their expertise and opinions are not valued

and their ‘farmer voices’ are not being heard. In addition, innovation that is contrast to normal growing practice, has been in the past actively discouraged. This contrast in understanding may lead to scepticism regarding the need to change practice. Practice change requires building a level of trust that is needed for positive long-term relationships (Eagle et al., 2016b, Section 1.3). Therefore it is recommended that business coaching be used to help extension officers to determine and receive professional development tools that might be beneficial to increase their engagement with land managers. It is important that business coaching is delivered through a consciously planned and facilitated delivery program rather than a self-enrol, self-managed delivery.

Workshops, Training and Other Activities

- Recognise land manager diversity but use typology principles to develop material and communication approaches to support extension officers.
- Build on the role of farmers whose views are respected as potential information gatekeepers / disseminators / role models.

Extension officers and land managers both identified that workshops and training were appropriate and useful. However, extension officers highlighted that best management practice workshops need to be held outside of the harvest season, that they should target skills deficiencies and be better coordinated with simpler processes (see Section 3.4). Land managers highlighted that the instructors need to be more knowledgeable, that programs are currently poorly targeted, and that people at the coal-face need to be more involved with the development of training practices. Land managers also called for more tailored delivery of programmes (see Farr et al., 2017b, pp. 49-59).

While the diversity of farmers and farming practice is acknowledged, it is useful to consider the role of typologies in developing resources to aid extension officers in their interactions with land managers through the identification of the range decision-making drivers and the types of land managers who are motivated by similar drivers (Graymore, Schwarz, & Brownell, 2015). Shrapnel and Davie’s (2001) five dominant personality styles may be used to direct learning (Figure 13).

For example, the “vigilant personality” values autonomy, therefore, may prefer a one on one approach to information gathering. Whereas the “solitary personality” feels comfortable alone, and prefers not to deal with people at all, therefore may suit an online learning environment or learning from trade magazines or television. The “serious personality” is not outgoing and does not like to be told things and would value information sharing in educated groups. By contrast, the “sensitive personality” is cautious when in groups and is stressed by unfamiliar surrounds; therefore, they would learn better in small groups of familiar people, such as extension staff (see Hay, 2018; Hay, Eagle, & Low, 2017).

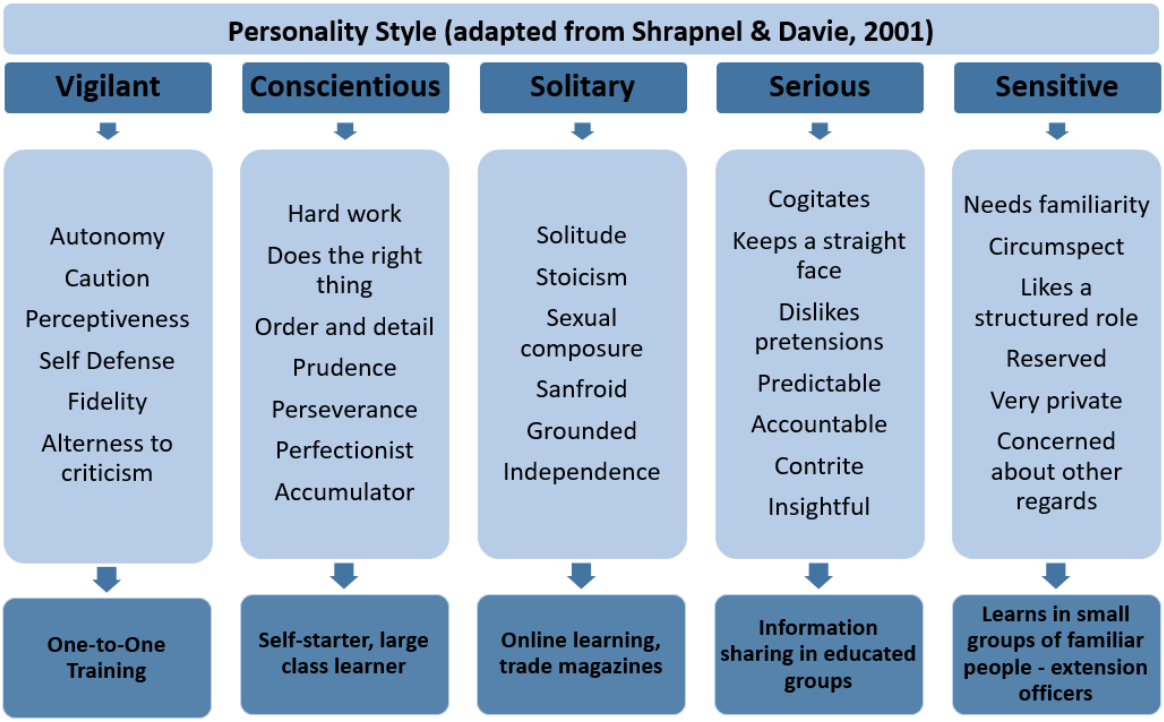

Figure 13: Farmer Typologies and Learning Preferences

We recommend that training programs be coordinated with land manager representatives of cane growing and grazing in the regions. We further recommend that training programs are themed towards the currently identified skills deficiency and that programs are developed towards best management practice and conducted outside of the harvest season. The final recommendation is to use the farmer typology and learning preferences to deliver training programs.

Perceptions of Causes and Pressure on Water Quality

- Ensure all communication, by whatever means, sends consistent messages irrespective of source, and channelling communication through trusted sources.
- Monitor media coverage and respond to inaccurate messages and develop proactive media relationships.
- Review communication strategies, adding social media where appropriate. Need to recognise the overall diversity of information sources and preferences.
- Proactive plans should be developed for combating or at least minimising the effects of competing and conflicting messages including negative media coverage (see Eagle et al., 2016, Section 2.7). We have reviewed media coverage of the Great Barrier Reef during 2016 (excluding tourism-related coverage). The findings indicate that the media presents a sensationalised and, at times, hostile perspective on reef-related issues (Eagle et al., 2018), although there was evidence that this was improving in the 2017 media analysis.

There are a range of competing and conflicting messages received by land managers, including largely negative media coverage of issues relating to the health of the Great Barrier Reef, and messages from mills and farm supply merchants. We note that information overload appears to be an irritating factor for some land managers and recommend that a system be

set up to monitor information from all sources and to combat messages that run counter to the desired core messages re: BMP.

We recommend that consistent messages be sent, irrespective of the source with key informants being involved in message design and delivery where possible. Ideally this would be as part of an integrated communications strategy (Dahl, Eagle, & Low, 2015), using a combination of both traditional and digital media (Batra & Keller, 2016; Keller, 2016) that encompasses federal, state and local-originated material and encompassed all forms of communication, whether print, electronic or face-to-face advice as part of this integration.

We note, however, that there is widespread distrust of government-originated information, therefore the source of information must be considered, along with the readability issues identified in our earlier report (Hay & Eagle, 2016) and also the communication channels preferred by land managers.

8.6 Recommendations Based on Third Round Data. Final Report: Findings from a longitudinal study of farmer decision influencers for Best Management Practices (Hay & Eagle, 2019)

The comparative analysis between first round and third round wet tropics and dry tropics data revealed small but positive changes in water quality management behaviour in both regions. There is a need to recognise the good work that land managers are doing to improve water quality. While, wet tropics cane growers identified 'having efforts recognised by the wider community' as important, cane growers in the Burdekin identified 'learning about and testing new ways of doing things on your farm/property' as important. Graziers on the other hand highlighted 'having time to pursue hobbies' as important. All three groups highlighted extension officers, family, and other graziers/growers as important to decision making. Recognising the difference in personality between cane farmers, graziers, and regions is important in developing resources to aid and extend increased uptake of BMP practices. Therefore, we reiterate the following recommendations:

- There is a need to recognise the key role that extension officers play in facilitation and sharing ideas with farmers and to determine what professional development support might be beneficial in continuing to build trust and engagement with land managers.
- It is crucial to support innovation by celebrating success and sharing ideas. Land managers should see their expertise is valued and their voices heard.
- Facilitate the sharing of ideas and practices
- Building on the role of farms whose views are respected as information gatekeepers / disseminators / role models.
- Recognise land manager diversity but use typology principles to develop material and communication approaches to support extension officers in their interactions with specific subsets of land managers.

8.7 Recommendations based on Data Collection and Analysis

It is recommended that data be collected using a longitudinal omnibus survey method, where data on a wide variety of subjects is collected during each phase of data collection, similar to Census data. Multiple clients or stakeholders can share the cost of conducting the research. Experiments can be timed to better suit cane growing and grazing practices to encourage participation. This may mean reducing the number of projects that are funded into the regions and concentrating more on repeating specific experiments over time to increase the reliability of the data. In addition, interventions or programmes in each region of the Great Barrier Reef Basin should follow a defined theme (i.e. one theme per funding round) so as to increase the measurability of theme specific interventions overall. In turn, other negative factors including survey fatigue and confusion caused by conflicting findings may then be reduced.

While the data was analysed using structural equation modelling (SEM), the findings are superficial due to theoretical and methodological gaps in the TPB model (see Section 5.3 for further explanation). The SEM measured wet tropics cane growers only and highlights positive influence of environmental goals on fertiliser application through lifestyle and social goals as well as 'farmers I respect most do this'. These findings are supported by the descriptive analysis contained in the third round results in Section 6.3. While the findings are positive, interesting, and relevant, it is recommended:

- That the data be further analysed by an expert data analyst alongside expert extension staff to gain a deeper understanding of the findings from the expert extension perspective to drill into the data to determine the depth of behaviour change.
- If the study is to be repeated, expert extension knowledge should be used to refine the questionnaire to maximise its utility to the extension community.

8.8 Conclusion

Cane growers in the Wet Tropics region have changed the way they calculate fertiliser application rates positively towards best management practices. For run-off practices, while the data indicates changes in the way that cane growers in the wet tropics are handling run-off, the results cannot determine if land managers are using best practice management techniques to handle run-off or some other method. Where previously, the wet tropics cane growers held a neutral stance that their industry plays a role in the declining health of the GBR, there is higher agreeance from wet tropics cane farmers about their industry's role in the declining health of the GBR. However, there still exists a tendency for wet tropics cane growers to shift the blame related to water quality and the health of the Great Barrier Reef to other organisations, industries, and individuals rather than consider their own practices as adding pressure to the GBR.

While cane growers in the Burdekin region have also changed the way they calculate fertiliser application rates positively towards best management practices. Less reported using industry standard rates in the final round of data collection (there has been an increase in the use of advisors and agronomists and the decision being dependent on cash flow, ground water, experience and budget has been highlighted, which may offer some explanation). While there have been changes in the tools that Burdekin cane growers are using to manage irrigation and to handle run-off, the results cannot determine if land managers are using best practice

management techniques for managing irrigation or handling run-off or some other method. Burdekin cane growers still hold a neutral view about whether or not nutrient loss from their property has an impact on water quality in local streams, rivers, or waterways. By contrast, there is more recognition from Burdekin cane growers that cane growing plays some role in the declining health of the GBR. However, similar to wet tropics cane growers, Burdekin cane growers tend to shift the blame related to water quality and the health of the Great Barrier Reef to other organisations, industries, and individuals rather than consider their own practices as adding pressure to the GBR.

The results from the Burdekin graziers data is less clear. While there was not enough data to compare the same grazier in 2016 to 2018 to establish if there had been a change in practices, (i.e. different graziers completed the survey in the first round and the third round of data collection) the results were fairly positive in terms of best management practice behaviour in drought conditions. The majority of graziers who responded to the survey were using best management and innovative practices that met the C/B, B, B/A criteria of the ABCD Framework, with the majority of graziers planning to do the same into the future. At the end of the study, there was higher agreeance that sediment loss from graziers' property was having an impact on water quality in local streams, rivers, and waterways compared to the beginning of the study and the graziers stance on their industry playing a role in the decline of the GBR moved from neutral towards agreement with the statement.

Expected Outcomes

The following expected outcomes were developed at the beginning of the program:

1) *WQ improvement programmes that are designed (and marketed) in ways that better match the motivations and values of land managers in the GBR.*

2) *Greater uptake/adoption of WQ improvement programmes with greater associated changes in behaviour; thus a greater return on investment.*

A change in language used in marketing material surrounding reef water quality was identified in second round analysis. Since then the project team has assisted NRMs and other stakeholders to review and alter their marketing communications to meet the recommendations.

The readability study and results combined with the best practice guide that was developed were adopted by both Terrain NRM and NQ Dry Tropics NRM to implement 'live' alterations to marketing and engagement strategies throughout the duration (and after) of the project to successfully engage with land managers. The alterations resulted in a greater uptake of water quality improvement programs in the NQ Dry Tropics region as evidenced in Section 7.4. The data analysis from the wet tropics shows incremental behaviour change in water quality management, which may evidence expected outcomes 1 and 2 to have been met.

3) *Insights about land managers and ways to tailor programmes to increase adoption that are transferrable to other contexts.*

Land managers and extension officers have indicated that holding workshops, training and other activities outside of the harvest season, targeting skills deficiency, and better-coordinated

systems would make the activities work better for land managers. Tailoring programs to improving land and soil management practices to raise awareness of water quality issues as well as accreditation and networking was highlighted as important to land managers. Nutrient management, soil chemistry, more involvement with extension officers and strategic coordinated extension programs with assistance from the DES would help in future to assist land managers to make farm improvements.

4) *Insights into ways of measuring the 'impact' of interventions that are transferrable to other contexts.*

It is apparent that there will always be confounding factors that will impact the measurement of any interventions actioned. As mentioned there are a multitude of competing and at times conflicting activities that are underway in both the Wet and Dry Tropics regions to improve water quality (see Section 3.0). It may be possible to subject research programs to themes in set periods so as to incorporate all programs surrounding one theme as a single intervention, which can then be measured for impact.

We also note a significantly increased level of media activity regarding the health of the Great Barrier Reef in 2017 compared to 2016, particularly as a result of two consecutive years of coral bleaching and a number of conflicting reports regarding the extent and consequences of this. In 2016, 242 relevant media items were analysed. In the period January – June 2017 alone, 743 items were collected for analysis. Given that the first round of data collection showed a high percentage of land managers did not believe their practices had any effect on the health of the Great Barrier Reef, this increased coverage is likely to reinforce and possibly even increase the land mangers' existing perceptions. This issue needs to be addressed as a matter of some urgency but is beyond the scope of this project.

It has been of concern throughout this project that some extension officers regard this project, and the data obtained from it, as purely an academic exercise rather than having any substantial relevance to their own activity. It was also noted that some extension officers have shown themselves to be resistant to change, while others feel that any form of innovation is actively discouraged by their organisations, resulting in significant levels of disillusionment among these staff. The relevance of the findings detailed in this and preceding reports should therefore be discussed with extension officers, with the discussion led by someone from within their own community who has the necessary skills. This individual can thus help shape the behaviour change within the relevant NRMs and other organisations that is necessary before behaviour change can be expected from land managers who are not fully committed to best land management practices. This should lead to co-creation, and thus stronger buy-in, from extension officers (and others) to the recommendations made in the reports provided for this project.

Upskilling of all relevant personnel (not just extension officers) is recommended in:

- The value of the application of relevant theory and communication frameworks to practice.
- The benefits of a social marketing approach to behaviour change initiatives (see the extensive discussion in the initial reports already provided for this project).
- The use of a range of social media platforms to communicate to stakeholders, and the importance of visual imagery in reinforcing key messages.

Given that the challenges noted in this report are not unique to the two participating NRMs, and the recommendations made in this report have application well beyond the two NRM areas, an upskilling program could be developed by the regional university, using digital platforms to deliver the program to a wide range of participants.

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APPENDIX 1: OVERVIEW OF SEM AND SUMMARY OF MEASUREMENT ITEMS

The development of the SEM goes back to the early 1920s (Wright, 1921) and was expanded in the 1940s to provide methodology where a combination of cause-effect information and statistical data could be used to answer policy related questions (Haavelmo, 1943). The SEM was further modified later in the century (Pearl, 1997) with refinements continuing into the current century (Pearl, 2003).

SEM is based on simple regression equations which are linear in parameters and which form a unified framework (Weis & Axhausen, 2009) but it is fundamentally different from a regression model. In a regression model there is a clear distinction between the dependent variable and independent variables. In SEM *"such concepts only apply in relative terms since a dependent variable in one model equation can become an independent variable in other components of the SEM system"* (Gunzler et al., 2013, p. 390).

A complete SEM contains the structural and the measurement equations. Those equations are defined by 'structural equations, measurement equations for endogenous variables, and measurement equations for exogenous variables' (Sharmeen, Arentze, & Timmermans, 2014, p. 164). *"Exogenous variables are always independent variables in the SEM equations' while endogenous variables can act as a dependent variable in 'at least one of the SEM equations...and may become independent variables in other equations"* within the SEM system of equations (Gunzler et al., 2013, p. 390).

Endogenous and exogenous variables can best be explained by a hypothetical example, for example when modelling fishing, the number/frequency of reef fishing trips would be classed as the dependent variable; as it depends on other variables including, boat ownership (boat owners are more likely to fish on the reef more often), and being male (males are more likely to go fishing more often). However, the influence of variables on each other may go both ways. Boat ownership, can be influenced by a willingness to fish on the reef and also by the frequency of fishing trips to the reef. Individuals who are willing to go fishing on the reef more frequently would be more likely to buy a boat to go fishing. As such, the boat ownership explains the number of reef fishing trips (the dependent variable) and the number of reef fishing trips explains the boat ownership. Therefore, the boat ownership, in this case, is endogenous. Put simply, boat ownership explains, but is also explained by the frequency of fishing trips. Whereas being male (exogenous variable) only explains the frequency of fishing trips and is not explained by the frequency of reef fishing trips.

The measurement equations within the SEM are used to specify an unobserved (latent) variables *"as a linear function of other variables in the system"* (Jahanshahi & Hall, 2013, p. 17). If those independent (explanatory) variables in a linear function are observed they are used as indicators of the latent variable. Factor analysis is often used to guide building of the measurement equations (Jahanshahi & Hall, 2013). SEM allows modelling and testing of the effects of all exogenous variables on all endogenous variables simultaneously or sequentially,

and also *"to account for both error correlations and direct effects between the endogenous variables'* at the same time (Weis & Axhausen, 2009, p. 3).

In SEM the arrows indicate paths that connect variables. *"When a path points from one variable to another, it means that the first variable affects the second"* (Statacorp, 2013, p. 7) (e.g. attitudes towards spelling paddocks depend on behavioural beliefs that it will improve land condition and will increase profits, Figure 15). The SEM approach can also measure the path relationships (the path diagrams show the relationships between the variables in SEM) within the TPB and indicate the relative significance of the paths between variables in the model (Deng et al., 2016; Molenaar, Washington, & Diekmann, 2000). This approach has also an ability to separate direct (direct influence of one variable on the other) and indirect (mediation) effects. A simple model with one mediator is shown in Figure 14.

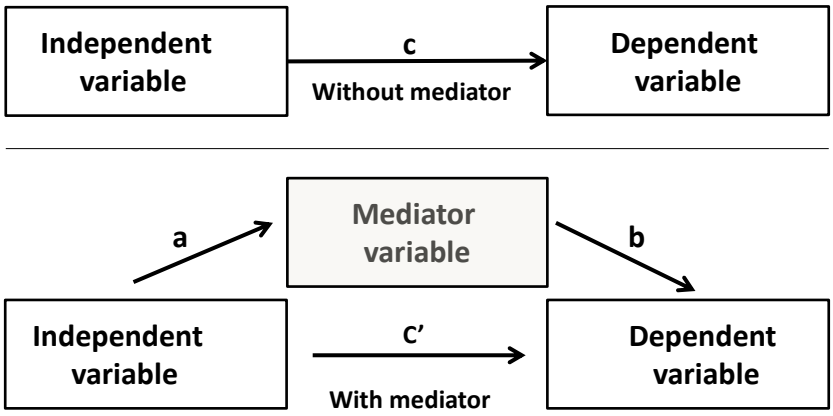

Figure 14: Simple statistical model with one mediator

An indirect effect is "*the effects along the paths between the two variables through one or more intervening variables"* (Jahanshahi & Hall, 2013, p. 17), which are often called mediator variables. Mediator variables are variables that *"sit between the independent variable and dependent variable and mediate the effect"* of the independent variable on the dependent variable (UCLA Statistical Consulting Group, 2017). The idea behind the analysis of mediation is that some of the effect of the independent variable is transmitted to the dependent variable through the mediator variable (Figure 14 path *a* and *b*). That portion of the effect that transmitted from the independent variable through the mediator is the indirect or mediation effect. Some portion of the effect of the independent variable goes directly to the dependent variable (Figure 14 path *c* and *c'*) which is a direct effect (Adams & Boscarino, 2011). SEM also allows one to estimate the total effect by summing indirect and direct effects between two variables (Byrne, 2016; Jahanshahi & Hall, 2013).

A simplified multilevel SEM based on the TPB is shown in the Figure 15. Boxes are observed variables with variable names written inside them (e.g. attitudes towards spelling paddocks, farm size). Measurement errors for each variable are given in circles at the bottom (e.1, e.2, e.3 etc.). Numbers next to the arrows are simultaneously/sequentially estimated coefficients and one star (10% level), two stars (5% level) and three stars (1% level) correspond to the statistical significance of the coefficient (e.g. estimated coefficient of perceived profitability 0.42** is positive and statistically significant at 5% level).

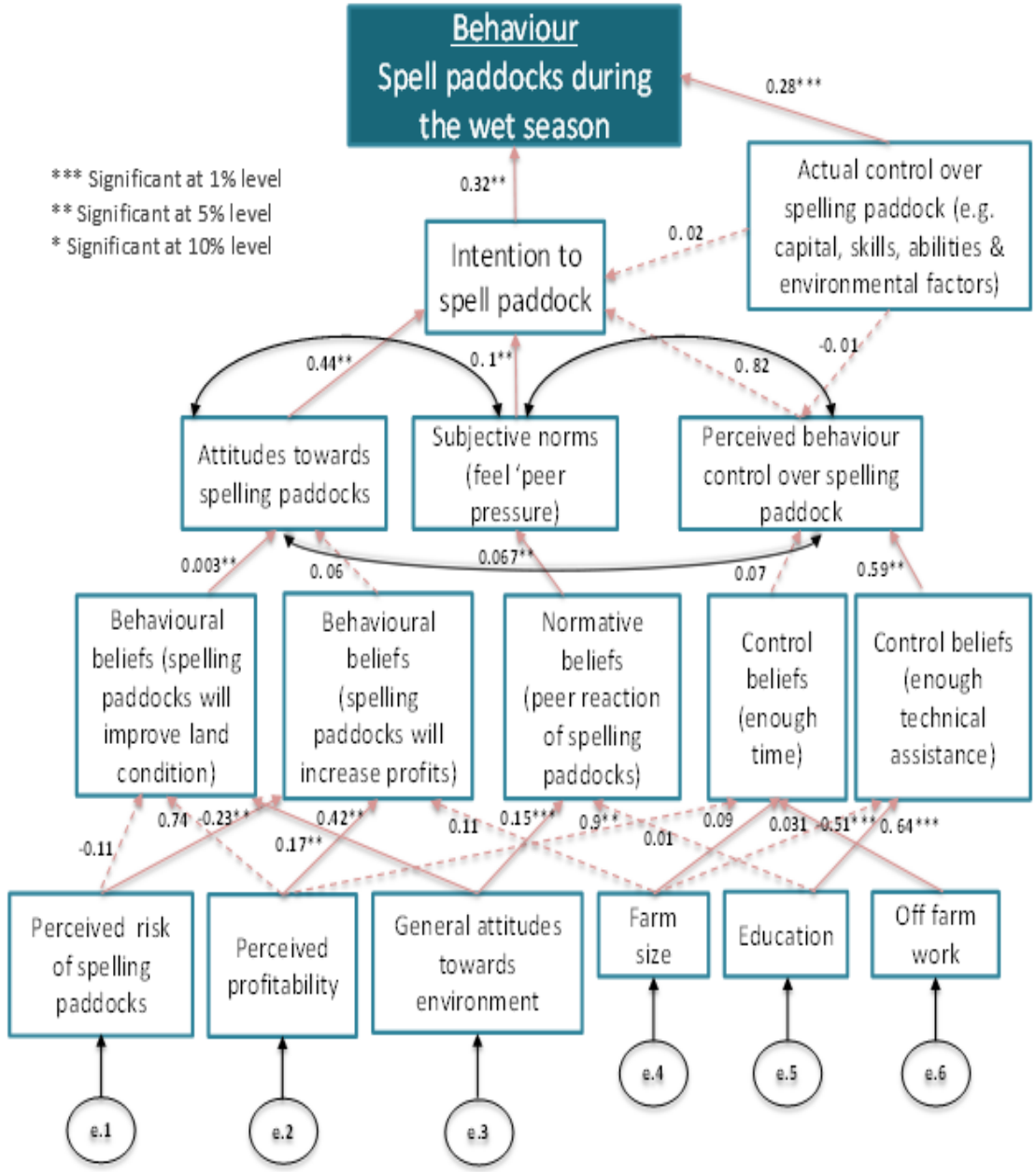

Figure 15: An example for simplified multilevel linear SEM based on the TPB

Attitudes towards spelling paddocks, for example, have indirect (mediated by intention) positive significant impact on actual behaviour. Actual control has a direct positive significant impact on actual behaviour (the estimated coefficient 0.28*** is positive and statistically significant at the 1% level of significance) implying that land managers who have actual control over their own capital and skills are more likely to perform actual behaviour (spell paddocks during the wet season) than those who do not (Figure 15). Perceived profitability is indirectly positively influencing behaviour through behavioural beliefs and attitudes towards spelling paddocks. However, looking at the magnitudes of the coefficient estimates (Figure 15), attitudes towards spelling paddock (estimated coefficient 0.44**) have the strongest direct impact on intentions to spell paddocks followed by subjective norms (0.1**) while perceived behaviour control (estimated coefficient 0.82 which is not statistically significant) does not have any direct significant impact on intentions.

The structural equation approach ‘‘assumes a direct causal relationships between certain dependent variables, and thus goes further than merely capturing these relationships via error correlations” (Weis & Axhausen, 2009, p. 17). The assumptions associated with SEM that ideally should be met to increase reliability of the results have been defined (Brain, 2008):

- all indicators in the model should be normally distributed (If this assumption is met, ‘the variance of the estimated parameters is consistently estimated by sample variances, but when it is not met, the standard errors of parameter estimates can be substantially underestimated, leading to false conclusions of significance’ (Bagley & Mokhtarian, 2002, p. 286; West, Finch, & Curran, 1995).
- latent variables should be measured by multiple indicators (variables)
- appropriate data imputation
- adequate model fit
- large sample size

However in practice, meeting these conditions is problematic (Bagley & Mokhtarian, 2002) and the normality assumption is often violated (Bentler & Dudgeon, 1996). Micceri (1898) reviewed various journal articles and datasets used in those studies within the SEM and found that in the majority of studies the conclusions were drawn from non-normally distributed data. (Breckler, 1990) and (Gierl & Mulvenon, 1995) also noted that it is very common for the researchers just *“to ignore the assumption of normality and to make conclusions as if the assumption were met”* (Bagley & Mokhtarian, p.286).

SEM is ‘fundamentally a hypothesis testing method (i.e., a confirmatory approach), rather than an exploratory approach (e.g., regression analyses)’ (Adams & Boscarino, 2011, p. 62). It has some advantages over other statistical models that are linear in parameters (Adams & Boscarino, 2011; Jahanshahi & Hall, 2013) (Golob, 2001) (e.g. hierarchical linear models such as random regression, linear mixed-effects, and multilevel model). SEM has a more and much broader *“interpretable array of measures of overall model fit, more flexible modelling of residual structures and of growth functions (e.g., typically, some slope loadings can be freely estimated parameters), and a better overall capacity to model latent variables and their multivariate associations”* (Curran, 2003; Tomarken & Waller, 2005, p. 38).

SEM allows:

- a series of regression equations being estimated simultaneously to control for how accurately the proposed model replicates the data (Byrne, 2010; Kline, 2010).
- ‘treatment of both exogenous and endogenous variables as random variables that may exhibit errors of measurement’ (Jahanshahi & Hall, 2013, p. 17).
- ‘accounting for the reciprocal influences of the endogenous variables on one another’ (Weis & Axhausen, 2009).
- Incorporation of observed (directly measured) and latent variables (Byrne, 2010; Kline, 2010).
- Latent (unobservable variables) can be modelled with multiple indicators.
- Separating of measurement and specification errors.
- Ability to test whole structural model and each coefficient individually.
- Modelling and testing mediating variables (mediators) and their effects.
- Ability to handle non-normal data as well as categorical variables.
- Ability to model and control for error term relationships.

Technical Foundations for Data Analysis: As TPB requires analysis of direct and indirect relationships of its constructs, the choice of analysis technique considers the approaches that provide analysis of both direct and indirect effects. Of the methods for analysing indirect (mediation) effects in behavioural theories, the approach of Baron and Kenny (1986) is the most frequently used (MacKinnon, Fairchild, & Fritz, 2007). As the outcome variable consisted of binary measurement, this study referred to the approach used by Desislava and Matilda (2011) for analysis of mediation effects with binary outcomes. The PROCESS macro for SPSS v 24.0 (Preacher and Hayes, 2004) was used in SPSS to analyse direct and indirect effects, which is very convenient and specifically appropriate when explanatory latent constructs are based on a single item (Preacher & Hayes, 2004a). The model estimation was performed by using Model No. 4 of Hayes' templates (Preacher et al., 2007) that provides estimates of indirect effects on the basis of upper and lower limit of confidence intervals, thus accommodating the traditional limitation of the power problem in Baron and Kenny's (1986) approach. To assess the statistical significance of the estimated paths, 5000 bootstrap re-sample and bias-corrected 95% confidence intervals (CI) were utilized (Preacher & Hayes, 2004b).

Construct	Items	Measurement coding
Fertilizer application behaviour	I use industry standard rates for district yield potential, and use that amount on all parts of my farm	Binary coding Six Easy Steps (industry standard) = 1 All other approaches = 0
	I use more fertiliser on high – performing (high yielding) blocks	
	I estimate amounts from my farm yield and use that amount on all parts of my farm	
	My advisor does this for me	
	I use more fertiliser on under-performing (low yield) blocks than on other blocks	
	I tailor my fertiliser rates to different parts of the property	
	Other, please tell us what you do	
Run-off handling behaviour	I have recycle pits	Binary coding Recycle pits = 1 All other practices= 0
	I do not capture run-off	
	I have recycle pits and have adequate pumping capacity to recycle the water	
	Other, please tell us what you do	
Attitudes towards behaviour	The best way to meet my own personal goals	Likert based measurement Strongly disagree = 1 Disagree = 2 Somehow disagree = 3 Neutral = 4 Somehow agree = 5 Agree = 6 Strongly agree = 7
	The best way to maintain good cash-flow	
	The best way to reduce business risk	
	The least time-consuming (or labour intensive)	
Perceived norms	The farmers I respect most do this	
Perceived behavioural control	The most effective way of controlling nutrient loss from my property	
	I only do this because I am forced to	
	The people/organisations whose advice I follow most think I should do this	
Lifestyle	Maintaining physical and mental health of family	
	Maintaining family traditions and heritage	
	Spending face-to-face time with family and friends	
	Keeping in contact with family and friends in other ways (e.g. via phone, through social media)	
	Maintaining good relations with other farmers/graziers in the local area	
Financial/economical control	Keeping farm costs low	
	Keeping a stable (steady) cash-flow	
	Maximising farm profits (income minus costs)	
	Minimising risk (of very high costs or very low income)	
	Servicing debt	
Social goals	Having time to pursue hobbies	
	Being able to make your own decisions about your farm/property	
	Learning about and testing new ways of doing things on your farm/property	
	Sharing new ideas with others	
	Having efforts recognised by the wider community	
Environmental goals	Leaving the land/farm in better condition than it was when you first started managing it	
	Maintaining/improving water supplies and storages	
	Minimising sediment run-off and/or nutrient losses	
	Helping to safeguard native plants and animals	
	Helping to safeguard local waterways	
	Helping to safeguard the Great Barrier Reef	

APPENDIX 2: INDEPENDENT SAMPLES T-TEST (SECTION 5.3.1)

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% CI	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff	Std. Error Diff	Lower	Upper
Maintaining physical and mental health of family	Equal variances assumed	3.055	0.081	1.466	315	0.144	0.181	0.123	-0.062	0.424
	Equal variances not assumed			1.288	96.58	0.201	0.181	0.141	-0.098	0.460
Maintaining family traditions and heritage	Equal variances assumed	2.474	0.117	2.085	314	0.038	0.377	0.181	0.021	0.733
	Equal variances not assumed			1.948	103.8	0.054	0.377	0.194	-0.007	0.761
Spending face-to-face time with family and friends	Equal variances assumed	0.027	0.869	0.545	315	0.586	0.074	0.136	-0.194	0.343
	Equal variances not assumed			0.547	114.0	0.586	0.074	0.136	-0.195	0.344
Keeping in contact with family and friends in other ways (e.g. via phone, through social media)	Equal variances assumed	0.202	0.654	1.837	312	0.067	0.329	0.179	-0.023	0.682
	Equal variances not assumed			1.904	120.5	0.059	0.329	0.173	-0.013	0.672
Maintaining good relations with other farmers/graziers in the local area	Equal variances assumed	1.682	0.196	2.336	315	0.020	0.289	0.124	0.046	0.533
	Equal variances not assumed			2.115	99.8	0.037	0.289	0.137	0.018	0.560
Keeping farm costs low	Equal variances assumed	0.253	0.616	0.391	315	0.696	0.051	0.129	-0.204	0.305
	Equal variances not assumed			0.382	110.1	0.703	0.051	0.132	-0.212	0.313
Keeping a stable (steady) cash-flow	Equal variances assumed	0.429	0.513	0.043	315	0.966	0.005	0.113	-0.218	0.228
	Equal variances not assumed			0.046	128.2	0.963	0.005	0.105	-0.203	0.213
Maximising farm profits (income minus costs)	Equal variances assumed	0.342	0.559	-0.165	314	0.869	-0.019	0.113	-0.241	0.204
	Equal variances not assumed			-0.173	121.3	0.863	-0.019	0.108	-0.233	0.196
Minimising risk (of very high costs or very low income)	Equal variances assumed	0.905	0.342	-0.583	315	0.560	-0.078	0.133	-0.340	0.185
	Equal variances not assumed			-0.612	122.2	0.542	-0.078	0.127	-0.330	0.174

Servicing debt	Equal variances assumed	1.934	0.165	1.585	309	0.114	0.301	0.190	-0.073	0.675
	Equal variances not assumed			1.575	113.5	0.118	0.301	0.191	-0.078	0.680
Having time to pursue hobbies	Equal variances assumed	0.406	0.525	-0.825	315	0.410	-0.163	0.197	-0.551	0.225
	Equal variances not assumed			-0.865	122.1	0.389	-0.163	0.188	-0.535	0.210
Being able to make your own decisions about your farm/property	Equal variances assumed	0.107	0.744	0.250	315	0.803	0.026	0.104	-0.179	0.231
	Equal variances not assumed			0.265	124.4	0.792	0.026	0.098	-0.169	0.221
Learning about and testing new ways of doing things on your farm/property	Equal variances assumed	0.959	0.328	0.785	315	0.433	0.091	0.116	-0.137	0.319
	Equal variances not assumed			0.780	112.5	0.437	0.091	0.116	-0.140	0.322
Sharing new ideas with others	Equal variances assumed	4.303	0.039	2.122	316	0.035	0.319	0.150	0.023	0.614
	Equal variances not assumed			2.005	107.1	0.047	0.319	0.159	0.004	0.634
Having efforts recognised by the wider community	Equal variances assumed	2.865	0.091	-1.924	315	0.055	-0.428	0.222	-0.865	0.010
	Equal variances not assumed			-2.112	135.2	0.037	-0.428	0.203	-0.828	-0.027
Leaving the land/farm in better condition than it was when you first started managing it	Equal variances assumed	1.147	0.285	-0.611	314	0.542	-0.060	0.098	-0.254	0.134
	Equal variances not assumed			-0.688	138.9	0.493	-0.060	0.087	-0.233	0.113
Maintaining/improving water supplies and storages	Equal variances assumed	0.032	0.859	0.253	276	0.800	0.060	0.236	-0.405	0.524
	Equal variances not assumed			0.255	125.6	0.799	0.060	0.234	-0.404	0.524
Minimising sediment run-off and/or nutrient losses	Equal variances assumed	3.537	0.061	2.067	312	0.040	0.227	0.110	0.011	0.444
	Equal variances not assumed			1.843	98.4	0.068	0.227	0.123	-0.017	0.472
Helping to safeguard native plants and animals	Equal variances assumed	3.003	0.084	1.526	312	0.128	0.224	0.147	-0.065	0.512
	Equal variances not assumed			1.392	102.9	0.167	0.224	0.161	-0.095	0.542
Helping to safeguard local waterways	Equal variances assumed	0.749	0.388	2.614	313	0.009	0.309	0.118	0.076	0.541
	Equal variances not assumed			2.241	95.8	0.027	0.309	0.138	0.035	0.582
Helping to safeguard the Great Barrier Reef	Equal variances assumed	0.538	0.464	2.572	313	0.011	0.326	0.127	0.076	0.575
	Equal variances not assumed			2.290	99.9	0.024	0.326	0.142	0.044	0.608

APPENDIX 3: EXAMPLES OF INNOVATIVE NUTRIENT MANAGEMENT PRACTICES, ANECDOTAL COMMENTS FROM WET TROPIC SUGAR CANE LAND MANAGERS, CODED

Code	Theme
1	Fertiliser/Bio Fertiliser
2	Alternative Crops/Irrigation
3	Headlands/Drains/Recycle Pits
4	Composting
5	Minimum Till
6	Stool Splitting Mixed Method
7	Best Management Practices
8	Green Trash Blanket
9	Laser Levelling

Examples of innovative practices, anecdotal comments from Wet Tropics land managers			
	1st Round		**3rd Round**
1	Adding humates/Split application of fertiliser and liquid fertiliser	**1**	apply mill mud/ ash subsurface under the stool at 25 tonnes a hectare
1	All fertilisers under soil	**1**	black urea at reduced rates of N
1	Alternate fertiliser	**1**	Black urea; variable rate fertiliser applications, lots of trialling
1	Bio fertiliser	**1**	Controlled Traffic, Nutrient Management Plans that use soil maps per block to give N recommendations.
1	Black urea	**1**	EEF Fertilisers on ratoons
1	Burying fertiliser	**1**	Enhanced efficiency fertiliser testing
1	Change to entec fertilisers	**1**	Mill mud, ash, I have allowed MIP to do water quality monitoring and install a bioreactor
1	Col gran to reduce volatility	**1**	Mix fertiliser with humid acid before applying
1	Delay fertilising, fertilise on weather	**1**	moved to subsurface application
1	EEF	**1**	place under ground
1	EEF's	**1**	Put a carbon souse with nitrogen
1	EEF's/Stool splitting/Zonal mill mud application/Minimum tillage	**1**	Slow release area
1	EFF variable rate application	**1**	split application and burying it
1	Entrench - help uptake/reduce loss of fertiliser	**1**	Split application of liquid fertiliser
1	Fertiliser at correct time, do not fertilise in wet	**1**	Subsurface application of fertilizers
1	Fertiliser incorporated in soil	**1**	Subsurface fertilizing and slow release nitrogen
1	Fertiliser is put underground; and we apply it when the weather is fine	**1**	Trailing a new fertiliser box attachment known as 'Stoolzippa" across a range of soil types to benchmark it's effectiveness

Examples of innovative practices, anecdotal comments from Wet Tropics land managers			
	1st Round		**3rd Round**
1	GPS rate control on fertiliser application	**1**	Trial of eek. Subsurface application, trash blanket, microbes
1	Humic acid and trace elements, trap N	**1**	Trialling Enhanced Efficiency Fertilisers; substituting mill mud for chemical fertiliser
1	Humic acid with Urea	**1**	trailing slow release fertiliser
1	I place my fertiliser under the trash in the ground beside the stool 2 row at a time 4 wheel that carry the 4 tonnes box the top where the fertiliser is put	**1**	trialling split application and lower rates of nitrogen
1	I put fertiliser underground will look at entech (fertiliser) in the future	**1**	Trying Entec, rate control on subsurface applicator, minimum tillage and controlled traffic
1	I use pelletised pouching manure as fertiliser in the cane with a N-content of 3.5% that is the best I can do	**1**	Use less nitrogen
1	Improving soil health by applying ash or compost	**1**	use mill mud a slow release fertiliser on ratoons
1	In bananas we use enhanced efficiency fertiliser and humates with our nitrogen	**1**	Use mill mud and bean crops to reduce the plant fertiliser rate
1	Interested in enhanced efficiency fertilising	**1**	Used enhanced efficiency fertilisers eg agromaster and entec
1	Irrigate in fertiliser with travelling irrigator	**1**	Uses Mill Ash where possibly but poor facilities at South Johnstone Mill
1	Lime regularly	**1**	Using biological amendments
1	Liming and mill ash - having all nutrient balanced mean less N is possible	**1**	Variable rate fertilizer box
1	Liquid fertiliser	**2**	Grow legumes crop and discounted nitrogen by not side dressing. Trial soil microbes
1	Liquid fertiliser, organic based proven to have 10% less N loss over 120 days	**2**	I utilise legume crops in my fallow and I account for this nitrogen in my plant crop
1	Liquid force fertiliser trace elements, organic humates and biology	**2**	Legume crop
1	Low nitrogen trials	**2**	legume planting, stool splitting, mound planting
1	Mill ash and mill mud on both areas ratoon	**2**	legume planting, stool splitting, mound planting, use of soil ameliorants
1	Mill ash with reduced N - but ash is very clean at $800/Ac often nice subsidy!	**2**	Legume planting, stool splitting, use of soil ameliorants
1	Mill mud on all ratoons/Trailing enhanced efficiency fertiliser	**2**	Legumes
1	Minimal or zero fertiliser in hollow areas/Spray out fallow	**2**	Legumes, considering using slow-release fertiliser
1	Place fertiliser underground	**2**	Legumes, I tried entec but did not see any economic benefit so won't be doing it again unless the price drops
1	Put fertiliser subsurface	**2**	reduced rates and multi species cover crops
1	Reduce fertiliser	**2**	wetland treating 50 ha of property run-off; legume cover crops in fallow
1	Refer to soil samples and utilise sub-surface when applying nitrogen	**4**	Developed an on-farm wetland; use cover crops; legume fallows (no bare fallows)
1	Side over and bury fertiliser/Used to use legume	**4**	Extensive wetlands > 100ha; trialling different fertilisers all the time

Examples of innovative practices, anecdotal comments from Wet Tropics land managers			
	1st Round		**3rd Round**
1	Slow release fertiliser (entec) or Nitro	**4**	Local drainage; cross-drains; a little sub-surface drainage. Molasses supplement to reduce nitrogen rates
1	Slow release fertiliser organic fertilisers	**4**	silt traps, variable rate and gps precision equipment, riparian zones, weather forecasting
1	Slow release fertiliser/Good fallow cover - no bare ground	**5**	Composting and legume fallow as revegetation of creeks and silt trapping drains
1	Sub soil stox application. Lonf size ratooning cycle	**6**	Zero Till planting reduced rates
1	Sub surface fertiliser/Maintain grass of headlands	**6**	Zonal tillage/stool split
1	Sub-surface application of fertiliser (stool splitter fertiliser box). This year also used Entec (slow release fertiliser)	**7**	Stool split fertiliser application
1	Subsoil application and slow release	**7**	Stool splitter to fertilize under ground
1	Subsurface	**7**	Stool Splitter, Enhanced Efficiency Fertilisers
1	Subsurface fertiliser, GCTB, mound planting, laser levelling	**7**	stool splitting, legume planting, use of soil ameliorants, mound planting
1	SVD surface fertiliser adp and zoal HOF	**8**	BMP accredited
1	Trailing entec/Calgreen below ground	**8**	Smartcane BMP and Composting
1	Trailing mill mud 28% reduction in bagged fertiliser in 2016	**9**	Trash blanket, sediment traps
1	Trialled entec, trialled liquid fertiliser - plant and ratoon	**10**	I have been laser levelling paddocks since the late 1990s
1	Trials with bio fertiliser, potassium		
1	Trials with EEF; liquid fertiliser; Turn N; Hibrix; low herbicides		
1	Tried control release fertiliser (EEF)/Variable rate fertiliser box (manage areas differently)/Would like to load at green siller		
1	Urea placed under ground always		
1	Use entec - 2 years trial		
1	Use humate with the nitrogen application		
1	Use lime/Mill mud and millash on occasion		
1	Use lots of lime		
1	Used entec year before last and legumes		
1	Using ENTEC		
1	Using high levels of mill mud		
1	Using mill mud on lat cut cane for slow N release		
1	Using some mill by-products		
1	Variable rate controller/Legumes/Mill mud/Crop age/Harvest time		
1	Variable rate fertiliser application		
1	Variable rate fertiliser application and experimenting on how to use this better		
1	Variable rate fertiliser application; timing of application		

Examples of innovative practices, anecdotal comments from Wet Tropics land managers			
	1st Round		**3rd Round**
1	Variable rate fertiliser box		
1	Variable rate nutrient application		
1	We began applying fertiliser underground instead of top dressing in 2017		
2	All our fallows are planted with legumes		
2	Ash/Fallow in soybean		
2	Fallow management with legumes/Entec slow-release fertiliser in 3rd pass harvest (Oct)		
2	Good cover crops/Diversion drains for water control		
2	Good fallow crops when possible or sprayout		
2	Good fallow with soy beans to reduce N needs		
2	High importance of legume fallow		
2	Legume crops in fallow		
2	Legume, controlled traffic, mound planting		
2	Peanut/Rice legume fallow		
2	Plant legume in fallow		
2	Use soybean fallow to reduce N in plant; Maintain trash blanket on fallow and ratoon crops		
2	Use t-tape for irrigation		
4	Adjusting soil pH/Spoon draining and re-direct water away from erosion lines/More headlands		
4	Are trialling Entec Urea. Changing flood irrigation system, re-jet cache pivot irrigator		
4	Cleaning and re-grassing drains; slow release fertiliser		
4	Developed wetland		
4	Drained sub-basin		
4	Grass headlands, silt traps, rock stabilisation		
4	Grass seeding sediment pit		
4	Grassed headlands/Vegetated drains		
4	Incorporating mill mud/ash; re-cleaning soil from headlands and drains		
4	Keep headland well grassed & mowed to hold sediment. All fertiliser goes underground here you can't afford to waste		
4	Mounding/EEF's		
4	Pastures and sediment traps, GCTB		
4	Timing of application and use of drainage to dry out paddocks		
5	Compost recycling/Legume fallow		
5	Composting - biosilids, tree mulch		
6	Fertilise at optimal time re weather and root growth - no till during wet season		
6	Minimum tillage		

Examples of innovative practices, anecdotal comments from Wet Tropics land managers			
	1st Round		**3rd Round**
6	Minimum tillage/cultivation		
6	Minimum tillage/Plant with zero fertiliser		
6	Minimum tillage/Reduced inorganic N application through use of mill mud/Legume fallow		
6	Zero tillage/Legume fallow/Trash blanket		
7	Split application with overhead irrigation		
7	Split stool variable rate application for fertiliser		
7	Stool spitter planting legumes		
7	Stool split		
7	Stool split apply fertiliser		
7	Stool split, EEF's, GCTB, mound planting, legumes		
7	Stool split, EEF's, mound planting, laser levelling, legumes		
7	Stool split, Entec, mound planting, legumes		
7	Stool split, legumes, laser levelling, mound planting		
7	Stool split, mound planting, legumes, sediment trap, laser levelling		
7	Stool split, mound planting, legumes, sediment traps, laser levelling		
7	Stool splitting, green cane trash blanket, mound planting		
7	Stool splitting - underground placement of nitrogen		
7	Stool splitting ratoon cane under soil		
7	Stool splitting some at the farm/Mill mud		
7	Stool splitting to capture N organic fertilisers		
7	Stool splitting, Aerocote - could not see any difference; Entrench - could not see any difference		
7	Stool splitting; EEF - Entee		
7	Stool splitting/EEF's/Mixed cropping/Mill mud		
7	Stool splitting/Granular fertiliser		
7	Stool splitting/Legumes/Control traffic/Uniform planting		
7	Stool splitting/Low N blends		
7	Stool splitting/Mill ash/Cousa crops/EE fertiliser		
7	Stool splitting/Mill mud and ash/Legumes		
7	Stool splitting/No till fallow/Trash blanket/6 Easy Steps		
7	Stool splitting		
8	BMP		
9	Green cane trash blanket/All fertiliser applied sub-surface		

Examples of innovative practices, anecdotal comments from Wet Tropics land managers			
	1st Round		**3rd Round**
9	Green trash blanket/Stool splittings for application/Spray out fallow/Legume cover crop		
9	Trash blanket, never burnt trash always incorporate trash into soil for fallow and plant legumes 25 years		
9	Trash blanket/Headlands		
9	Trash to make earth walls in gullies and washouts		
10	Laser levelling/Traffic control/New probes		
10	Precision Ag		
10	Laser levelling		

APPENDIX 4: EXAMPLES OF INNOVATIVE NUTRIENT MANAGEMENT PRACTICES, ANECDOTAL COMMENTS FROM DRY TROPICS SUGAR CANE LAND MANAGERS, CODED

Code	Theme
1	Fertiliser/Bio Fertiliser
2	Alternative Crops/Irrigation
3	Headlands/Drains/Recycle Pits
4	Stool Splitting/Mixed Method
5	Best Management Practices
6	Applied Humates
7	Automated Flood System
8	Water/Soil Testing

Examples of innovative practices, anecdotal comments from Dry Topics land managers			
1	Applying mill mud and applying fertiliser banded into the cane stool	**1**	Fertilizer boxes to make sure nitrogen is in the ground. put mud and ash in the ground
1	GPS rate control and placement	**1**	Variable rate gps controllers for fertiliser and chemical control. Capture most of my run-off except for after rain events which is time consuming
1	Slow release fertilizers	**1**	When we have previously grown 'organic bananas' we used a lot of natural products, chicken manure, fish scrapes. pinto peanuts.
1	The placement of fertiliser and where it gets put in the paddock - right heights so water doesn't leach it out. Minimise leaching.	**2**	Legume Crops
1	Waiting a specified time to irrigate after fertiliser has been applied and keeping Run-off to a minimum for the first 3 irrigations	**2**	Placement of nitrogen, drip irrigation, growing pulses-small increments over a long time.
2	EM Surveys and Legumes	**2**	Planting legumes, banded mill mud and banded sub surface mill mud applications
2	Hole fills up with overflow - council classed as sediment trap. Put crop on fallow to minimise run-off	**2**	Solid fertilizers I place them in the soil close to plant. Use cover crops to help stop Run-off. Useful to stop soil runaway during floods. Can make money from that cover crop. Trickle irrigation - actually used more water. Things need to be studied as a whole. Feels like more questions could have been asked.
2	Overhead irrigation, variable rate control.	**3**	I use end banks and grassed headlands

3	Trash incorporator - he wasn't sure of name. Destroy hill, cultivate fertiliser into it, rebuild hill with topsoil. Target at roots. No fertiliser in atmosphere - otherwise evaporation and waste money.	**3**	Series of lagoons to capture sediment Run-off
4	Double disc openers, Variable Rate controllers,	**4**	Placing fertilizer up on the hill & foliage spray. Stool split fertilizer.
4	Green cane harvesting, covered crops, beans, spoon drains, minimum tillage	**5**	Not sure what this question means i have been at best practice all my farming life and i am quick ot change as new information becomes available.
4	I use a stool splitter to fertilize my cane,	**5**	When we surface apply liquid fertiliser we do so in two narrow bands either side of the crest of the hill. The idea of this is the put it in the zone where it will get wet by irrigation water soaking up to it but will be high enough out of the water furrow so that irrigation water won't wash it away. We also delay irrigation for 10-15 days after fert application to reduce losses as research has shown this helps. We have been involved in various nutrient run-off initiatives over the years and are always adjusting our practices to the latest research in this area.
4	Stool split disc openers, zero tillage bi annually, end banks,	**6**	I apply humates with the fertiliser application to stabilize the nutrients from leaching
4	Stool splitter	**7**	Automated irrigation
4	Stool splitting, minimum stillage,	**8**	Continuous nitrogen monitor, connected to weather system. I track any leaking nitrogen in system.
5	Grant to improve farming practices		
5	Integrated system where the land and water resources come before financial wealth,		I do not have nitrogen Run-off from my farms. I am very, very insulted that everyone assumes I am wrecking the reef. Pisses me off. I love the reef. Please check the science. It is wrong
6	Put fertiliser at top of hill so doesn't Run-off. Uses 'humate' carbon to help slower release fertiliser		
6	We add soluble humates and soil microbes as the fertilizer is placed in the ground		
7	Designing an automated system for flood irrigation		
8	Water sampling/testing, soil testing, government data for bore regiments		

APPENDIX 5: EXAMPLES OF INNOVATIVE RUN-OFF MANAGEMENT PRACTICES, ANECDOTAL COMMENTS FROM BURDEKIN GRAZING LAND MANAGERS, CODED

Code	Theme
1	Contouring banks
2	Erosion Prevention Project
3	Riparian Zone Management
4	Maximum Pasture Management
5	Gully Management
6	Grazing Management Practices
7	Fencing
8	Nothing, stopped by GOV regulations

Examples of innovative practices, anecdotal comments from Burdekin grazing land managers		
1st Round		
Blade ploughing, contour banks	1	1
Completed an erosion prevention project with NQDT	1	2
Minimise stock to help with growth, in future plant trees in bare areas, soil samples to improve soil.	1	2
Put in small deviation bank and tracks - use Darrel Hills methods - own grating system	1	2
Seeded, cleared, soil management on roars, repaired breakaway country, seeded clay pans	1	2
Try to put down sticks and regenerate species.	1	2
We do remedial work on badly eroded areas * (These areas are from constant stocking under previous management)	1	2
Don't burn, look after riparian areas by only grazing while there is sufficient feed, waterways are all fenced	1	3
Maximum pasture management is the best we have at the moment	1	4
The best way to reduce Run-off is by land clearing do that the grass can hold the soil	1	4
Filling gully heads with rocks/sand etc. to reduce speed of Run-off into the eroded areas	1	5
Putting logs in gullies	1	5
NO BLADES ON THE GROUND. FENCE TO CONTOUR WHERE PRACTICAL	1	6
Off stream water, fencing water ways, adjusting stocking rates. This land type doesn't have too much run-off issues either	1	6
Will fence off areas if needed	1	6
Survey road placements and utilise contour banking - use slopes. We have a weed management practice that minimises the impact of weeds of high stock/high traffic areas. Pest eradication program e.g. Macropods, to minimise grazing pressure from non-controlled species.	1	0
Wanting to		
Total	16	15

3rd Round		
Contour ripple prevents run-off	1	1
Cutter bar - breaks the soil up, creates a good seed bed, and leaves it lumpy to capture water run-off. Retains the water and the old leaf /feed material does not get washed away, it stays on the soil. The best way to improve the soil condition.	1	2
Pondage banks	1	2
Put woo boys when making roads	1	2
Hoof Impact on scaled areas. Careful management of pastures	1	4
Just ground cover in areas prone to fast Run-off	1	4
Spraying wood weeds to encourage grass growth along waterways	1	4
No major water ways on block. We do try to reduce gully erosion by using conservative stocking rates and reduce road erosion by using well-constructed roads with diversion drains	1	5
Try and fill in whenever it erodes.	1	5
Grazing practice - two lots of breeders combined to 2 mobs, shift from one paddock to another over a period time depending on paddock size, and keeps them moving depending on the grass regrowth more regularly	1	6
Provide watering points away from waterways as there is no permanent water	1	6
Using cattle as a tool to improve the ground cover & soil structure is the only practical approach	1	6
Fence according to soil types and what is required i.e. if it's more prone to erosion. Off stream watering points	1	7
Gov regulations prevents us developing full sediment control systems. Example; invented native species numbers habitat in our area veg management laws prevent sediment run-off programs	1	8
Total	14	

APPENDIX 6: TOP CAUSES OF POOR WATER QUALITY IN LOCAL STREAMS, RIVERS AND WATERWAYS, ANECDOTAL COMMENTS FROM WET TROPICS LAND MANAGERS, CODED

Code	Theme
1	Farming (Banana, Cane, Grazing and Fruit Growing)
2	Erosion
3	Bare ground
4	Blockages in creeks, cleaning creeks and drains
5	Construction/Civil Works
6	Climate Change/Global Warming
7	Cultivation Practices
8	Weather/Natural Run-off/Floods/Rainfall
9	Feral Animals (Pigs)
10	No poor water quality
11	Illegal dumping/Accidental Spills/Pollution
12	Urban Development
13	Other Industry or Government
14	Run-off
15	Don't know

What are the top causes of poor water quality in your local streams, rivers & waterways?												
1st Round						3rd Round						
	Code	n		Code	n		Code	n		Code	n	
A little from cane farms - most sediments come from up-stream	1	1	5% of farmers not following proper practices	1	1	Banana growers	1	1	Agricultural run-off	1	1	
Banana farm harvesting in wet weather	1	1	Badly managed fallow	1	1	chemical contamination	1	1	bam a farms	1	1	
Banana farmers working ground in wet season	1	1	Banana farm run-off chemicals into waterways Aerial spraying and fertilising	1	1	Fruit growers	1	1	Banana bags	1	1	
Banana farms	1	5	Banana farms	1	3	Fruit farmers sediment	1	1	Banana farmers	1	1	
Bananas	1	2	Banana growers	1	2	Fruit growers causing high sediment load	1	1	chemical and sediment	1	1	
Bananas, traitors fertiliser, chemicals	1	1	Bananas	1	1	N Losses	1	1	chemicals	1	1	
Break down of carbon - trash blanket	1	1	Cattle farming	1	1	Nutrient	1	1	Graziers	1	1	
Cane farming	1	1	Chemicals	1	1	Nutrient loss	1	1	Grazing	1	1	
Cane harvesting in the wet	1	1	Erosion used in bananas	1	1	Nutrients	1	1	Leaching of nutrients into ground water	1	1	
DIN	1	1	Excess nutrients from agriculture	1	1	Nutrition in water	1	1	Nutrient and herbicide run-off	1	1	
Farm and bank erosion; lots of drainsin vegetation	1	1	Fertiliser & chemicals	1	1	sediment loss from Bananas	1	1	nutrient contamination	1	1	
Farming practices	1	1	Fertilising on top of ground and having at run all over end of headlands	1	1	Sugar cane farming	1	1	Pesticides	1	1	
Fertiliser practices	1	1	Increased nutrient loads	1	1	The few cowboys that are still out there	1	1	Poor farming methods	1	1	
Fruit growers	1	1	Lack of control on timing of farm practices through external resources	1	1	Up-stream farmers	1	1	Bank Slumps	2	1	
Hobby farmers	1	1	Lack of sediment traps	1	1	erosion	2	3	Erosion	2	3	
Inappropriate spraying	1	1	lack of silt traps	1	1	Erosion	2	2	Erosion - sediment	2	1	
Intensive livestock farming	1	1	Less opportunity for fertilising at the right time	1	1	erosion causing sediment	2	1	Soil erosion	2	1	

What are the top causes of poor water quality in your local streams, rivers & waterways?											
1st Round						3rd Round					
	Code	n		Code	n		Code	n		Code	n
Lack of fallow crop	1	1	Longer season length greatly increases risk of ill-timed fertiliser application	1	1	Erosion from local roadways	2	1	Bad drainage	4	1
Lack of riparian vegetation	1	2	Nutrient losses	1	1	erosion in rivers	2	1	Local creek full of aquatic life	4	1
Late finish to harvets spraying	1	1	Nutrients flowing out of suburbs	1	1	Erosion	2	1	poor or no stream maintenance	4	1
Late harvest	1	1	Often agricultural industries are not regulated as such as cane	1	1	river bank slumping	2	1	Poorly maintained drainage systems	4	1
May be chemical	1	1	Over application of fertiliser and chemicals	1	1	riverbank erosion	2	1	waterway connectivity	4	1
Mill closures - extended cutting	1	1	Pesticides	1	1	Riverbank erosion	2	1	weeds	4	1
Nutrient loss	1	1	Poor quality riparian vegetation	1	1	Upstream erosion caused by heavy rainfall	2	1	Climate change	6	1
Nutrient; bananas	1	1	Poor riparian vegetation	1	2	Exotic weeds	4	1	Cultivation of land	7	1
Pesticide load	1	1	Rubbish - banana bags, irrigation pipe	1	1	Hymenachne grass	4	1	Poor cultivation practices	7	1
Poor farming practices	1	1	Sugar in the cane trash is a big polluter	1	1	Invasive weeds	4	1	Floods	8	2
Poor riparian management	1	1	Wildlife and landholders in the up-stream of the farming area	1	1	Plant material accumulation in waterways	4	1	Heavy floods	8	1
Poorly applied fertiliser/chemical - other farmers not me)	1	1	Banks collapsing	2	1	Stagnant waters	4	1	High flooding in wet season	8	1
Run-off from banana farms	1	2	Erosion from roads	2	1	Unstable banks on Liverpool Creek	4	1	high rainfall	8	1
Sediments/Nutrients/Chemical run-off	1	1	Erosion of creek banks	2	1	Climate change	6	1	High rainfall	8	1
Surface application of fertiliser	1	1	River bank erosion	2	1	Cultivation for cropping	7	1	High rainffall	8	1
Up-stream farming practices	1	1	Any exposed soil (e.g. pigs, roads, cow paddocks etc.)	3	1	Erosion, cultivation at inappropriate times	7	1	High volume rainfall	8	1
Upper catchment	1	1	Bare horticultural land	3	1	land mismanagement	7	1	Massive rain events	8	1
Upstream activities	1	1	Bare paddocks	3	1	Colour of local soil	8	1	Natural disasters	8	1

What are the top causes of poor water quality in your local streams, rivers & waterways?										
1st Round						3rd Round				
	Code	n		Code	n		Code	n		Code	n
Bank erosion	2	2	Due to overgrazing; lack of cover from fires and overgrazing; also heavy storms	3	1	Cyclones	8	2	Rainforest nutrients	8	1
Bank erosion from high bank	2	1	Lack of ground covers	3	1	Cyclones	8	1	Run-off from Massie rainfall events	8	1
Erosion	2	4	Poor bank stability	3	1	Excess flooding	8	1	Run-off from rainforest, woodlands, roads, drains and urban development	8	1
Erosion from all sources - feral pigs	2	1	Uncovered fallow	3	1	Extreme rainfall events	8	1	Tannins from swamp leaves: Not permitted to burn swamps so leaf litter has built considerably	8	1
In wet season bank erosion	2	1	Working your soil	3	1	Extreme weather events	8	1	Feral pigs in world heritage	9	1
Loose soil	2	1	Choked waterways	4	1	Flood	8	1	Pigs	9	2
Rangelands erosion - tablelands	2	1	Invasive weed and urban	4	1	Flooding	8	2	Pigs	9	1
River bank erosion	2	1	Lack of funding to inhibit pest weeds in waterways	4	1	Flooding	8	2	Pigs and vermin	9	1
Soil erosion	2	1	Local Council - don't maintain drains	4	1	FLOODING	8	1	Pigs digging up stream banks, paddocks	9	1
Soil loss	2	1	Poor drainage	4	1	Floods	8	2	Wallabies	9	1
Soil movement	2	1	Poor flow is vary by conditions	4	1	Heavy rainfall	8	1	Who says the water quality is poor?	10	1
Soil run-off/erosion	2	1	Poor flow path due to fallen trees	4	1	Heavy rainfall area causing soil erosion	8	1	Human encroachment	12	1
Soil types (not holding nutriens)	2	1	Sediment build up in waterways	4	1	Heavy rainfall with soil erosion	8	1	Roads poorly drained into waterway	12	1
Top soil erosion	2	1	Unable to burn swamps. All reef water makes water black	4	1	High rainfall events	8	1	Run-off from the high way	12	1
Bare fallow	3	1	Weeds	4	1	huge downpours of rain	8	1	Secondary treatment sewerage plants	12	1
Bare ground	3	1	Broken flood gate up to 3m tides	5	1	Major flood events	8	1	Urban development	12	1
Bare soil	3	1	Local Council and main roads	5	1	Major flooding	8	1	Urban encroachment	12	1

What are the top causes of poor water quality in your local streams, rivers & waterways?												
1st Round						3rd Round						
	Code	n		Code	n		Code	n		Code	n
Erosion from bare fallow	3	2	Cultivation during wet season	7	1	Run-off from upper catchment	8	1	Urban encroachment	12	1
Un-grassed headlands	3	1	Excessive cultivation	7	1	Run-off from world heritage areas	8	1	Urban run-off	12	1
Unsealed roads	3	1	Farming practices - too much tillage	7	1	The nature of the catchment: high rainfall with rapid run-off	8	1	Urban run-off	12	1
Unstable river banks	3	1	Farming systems	7	1	upper catchment Run-off	8	1	local authorities and government departments	13	1
Unsurfaced roadways - run-off	3	1	Inappropriate timing of cultivation	7	1	upper catchment run-off	8	1	Poor conservation practices	13	1
Blockages in creeks	4	1	Poor fallow management on steeper terrain	7	1	upstream erosion	8	1	sediment	14	2
Cleaning the community waterways to reduce stagnant water	4	1	Poor farm layouts: leading to ...	7	1	Very high rainfall events	8	1	I don't know	15	1
Creeks need cleaning	4	1	Poor farming practices (e.g. full tillage)	7	1	Feral pigs	9	1	Total		64
Grass infested- lack of cleaning subsidy	4	1	Poor tillage practices	7	1	Feral pigs causing sediment	9	1	a. Round of data = 3		
Hymenachne	4	1	Tillage	7	1	pigs	9	4			
Hymenachne clogs up drains, then floods into paddock	4	1	Timing of fallow crop planting	7	1	Pigs	9	9			
Introduced water weeds and grasses	4	1	Application of herbicied around flood event	8	2	Pigs errosion	9	1			
Introduced weed species	4	1	Cyclones	8	1	Sedimenet run-off from pig damamged soil	9	1			
Introduced weed species and grasses	4	1	Debris-Forrest	8	1	soil and pigs	9	1			
Invasive introduced weeds species and hymenachne	4	1	Extreme weather - lanslides in world heritage	8	1	soil reosion from state forests (pigs)	9	1			
Lack of flow	4	1	Flooding	8	1	Don't believe there is an issue from our farm	10	1			
Overfertilising and stagnent water from swamps	4	1	Heavy rain from the rainforest	8	1	don't feel there is poor water quality in local waterways	10	1			

What are the top causes of poor water quality in your local streams, rivers & waterways?											
1st Round						3rd Round					
	Code	n		Code	n		Code	n		Code	n
Poor cleaning of drains and creeks	4	1	Natural run-off	8	1	Farmers water is good quality and quite drinkable	10	1			
Poor drainage	4	1	natural run-off from upper catchment	8	1	I would not say that local streams have poor water quality	10	1			
Removal of swamps, lack of buffers	4	1	Nutrients from rainforest	8	1	Council and tMR sending water from subdivisions	12	1			
Stagnant waters coming from sugars in cane block (from harvesting), vasted product	4	1	Old forestry tracks	8	1	Roadside run-off	12	1			
Streams clogged with weeds pests	4	1	Our massive wet seasons	8	1	sediment and nutrients - from towns	12	1			
Weeds in channel and local creek	4	1	Run-off non-farming areas	8	1	Sewerage works	12	1			
Weeds within streams and banks	4	1	Severe weather conditions	8	1	Town	12	1			
Civil construction	5	1	Stream erosion by nature (cyclones)	8	1	town communities	12	1			
Council roadworks	5	1	The upper Herbert catchment	8	1	town waste	12	1			
Climatic events	6	1	Water from rainforest (higher volume) flowing through paddocks	8	1	Urban development	12	2			
Cultivation at the wrong	7	1	Disturbance of natural parks - feral animals	9	1	Run-off	14	1			
Cultivation at the wrong time	7	1	Erosion from feral animals. Some from farming activity-sediment	9	1	sediment	14	1			
Cultivation at the wrong time - grower	7	1	Feral animals	9	1	Sediment Run-off	14	1			
Cultivation of plant cane	7	1	Feral pig intrusion	9	1	Don't Know	15	1			
Debris from national parks	8	1	Feral pigs	9	4	I don't know	15	1			
Erosion from national parks	8	1	Feral pigs in rainforest	9	1	Total		103			

What are the top causes of poor water quality in your local streams, rivers & waterways?										
1st Round						3rd Round				
	Code	n		Code	n		Code	n		Code	n
Flooding	8	4	Large amounts of erosion from pigs damaging creek banks	9	1	a. Round of data = 3					
Floods	8	3	Pig damage	9	1						
Heavy rain	8	1	Pig damage in national parks	9	1						
Heavy rainfall	8	2	Pig damage in wet season	9	1						
Heavy rains at time of cultivation	8	1	Pigs in national parks	9	1						
High every season rainfall (stroms) after dry weather	8	1	Run-off from national parks from pig damage	9	1						
High rainfall	8	1	Tilapia in the stream (once full of bana) and tilapia dig the banks	9	1						
Landslides in World Heritage - nutrient run-off	8	1	Unstable banks and pigs	9	1						
National park run-off	8	1	Farm - how do we know	10	1						
Natural erosion from forested areas	8	1	I would like to see proof of the water quality in our local area	10	1						
Natural rainforest run-off	8	1	There are more fish than when I was a kid	10	1						
Natural run-off	8	1	Accidental spills	11	1						
Raw forest above us	8	1	Coastal pollution	11	1						
Rotting debres	8	1	Chemicals from townships	12	1						
Steep forested ranges - erosion	8	1	High run-off volumes from urban development	12	1						
Steep terrain	8	1	Human ache	12	1						
Torrential rain	8	1	Litter from the highways	12	1						
Wet weather events	8	1	Overflow from main roads highway	12	1						
Excessive rainfall, feral pigs, land slips	8	1	Population growth	12	1						
Extreme weather	8	3	Timing of development	12	1						

What are the top causes of poor water quality in your local streams, rivers & waterways?											
1st Round						3rd Round					
	Code	n		Code	n		Code	n		Code	n
Extreme weather events	8	2	Urban development	12	9						
Weather conditions	8	1	Urban development on slopes	12	1						
Feral animals	9	2	Urban run-off	12	4						
Feral animals in natural areas - erosion	9	1	Urban systems	12	2						
Feral pig damage in national parks	9	1	Weekend warriors in 4-wheel drivers	12	1						
Feral pigs	9	12	Government infrastructure construction	13	1						
Feral pigs a wildlife still matter4 in rainforest (Wet Tropics)	9	1	National park neglect	13	1						
Feral pigs eroding in national parks	9	1	Saltation	14	1						
Feral pigs in national parks - disturbance	9	1	Sediment loss	14	1						
Feral pigs in rain forest	9	1	Awaiting results of project 25	15	1						
Feral pigs in world heritage	9	2	Fuel 2 weeks		1						
Feral pigs in World Heritage	9	2	Total		136						
Pig damage	9	4	a. Round of data = 1								
Pig damage - allow greater amount of sediment of my farm	9	1									
Pig damage in national parks	9	1									
Pig damage in national parks & shrub	9	1									
Pigs	9	1									
Run-off from naturak areas - pigs	9	1									
Sediment from damaged banks including pig damage	9	1									
Sediment loss from rainforest and pigs	9	1									
Wild pigs	9	1									

What are the top causes of poor water quality in your local streams, rivers & waterways?										
1st Round						3rd Round				
	Code	n		Code	n		Code	n		Code	n
Wild pigs in rainforest	9	1									
I do not beleive the waterways are of poor quality	10	1									
I do not think that tha water quality is poor	10	1									
I don't think we have poor water quality	10	1									
I have not send samples of our run-off away to get tested	10	1									
Local streams are pretty good	10	1									
Need more study	10	1									
No problem with the water	10	1									
The weather quality is not poor	10	1									
What is the evidence of poor water quality in my local stream, river?	10	1									
Without individual water quality testing on	10	1									
By estimation water quality is not poor. I have a healthy habbit	10	1									
Increased run-off from urban development	12	1									
Increased urban encroachment	12	1									
Run-off farms, natural parks, urban areas	12	1									
Sewage plants	12	1									
The whole community	12	1									
Urban development	12	3									
Urban development - new subdivisions	12	1									
Urban run-off	12	5									
Urban use - no filters on run-off community/town use	12	1									
Illigal dumping - local problem	13	1									

What are the top causes of poor water quality in your local streams, rivers & waterways?										
1st Round						3rd Round				
	Code	n		Code	n		Code	n		Code	n
Water from Government land	13	1									
Other industries	13	1									
Government own asset (uprooted trees in river/erosion). I can't measure the quality of water leaving my farm	14	1									
Run-off	14	1									
Run-off from properties up-stream	14	1									
Run-off into headwaters	14	1									
Run-off of dust caused by any spills	14	1									
Sediment	14	3									
Sediment and natural matter from upper catchment	14	1									

APPENDIX 7: TOP PRESSURES ON THE HEALTH OF THE GREAT BARRIER REEF, ANECDOTAL COMMENTS FROM WET TROPICS LAND MANAGERS, CODED

Code	Theme
1	Farming (Banana, Cane, Grazing and Fruit Growers)
2	Erosion
3	Fishing/Shipping/Tourism
4	Blockages in creeks, cleaning creeks and drains
5	Construction/Civil Works
6	Climate Change/Global Warming
7	Cultivation Practices
8	Weather/Natural Run-off/Floods/Rainfall
9	Feral Animals (Pigs)
10	No poor water quality
11	Illegal dumping/Accidental Spills/Pollution
12	Urban Development
13	Other Industry or Government, Research
14	Run-off/Sediment
15	Acidification/CoT/Bleaching
16	Don't know

What are the top two pressures on the health of the Great Barrier Reef?											
1st Round						3rd Round					
	Code	n		Code	n		Code	n		Code	n
Chemicals	1	1	Agriculture	1	3	bananas	1	1	agriculture adjacent to reef	1	1
Fertiliser	1	1	Banana farming	1	1	Bulk Shipping	3	1	farming	1	1
Fertiliser and chemicals	1	1	Exploration of farming	1	1	Pro Fishermen	3	1	farming	1	1
Fertiliser placement on top of stool	1	1	Farming systems	1	1	snorkelling	3	1	Overfishing	3	1
Herbicides application on timing	1	1	Fertiliser and chemicals	1	1	sunscreen on tourists	3	1	overuse of asset	3	1
Horticulture farming in the district in wet weather	1	1	Fertiliser run-off	1	1	Too many people visiting the reef	3	1	Shipping	3	1
Not enough nutrients	1	1	From farming and natural parks overrun by feral pest/pigs.	1	1	tourism	3	3	sun screen	3	1
Other agriculture	1	1	Land usage practices but these are getting better and better	1	1	Tourism	3	2	tourism	3	2
Run-off from all types of farming properties, sediment loss, urban/town areas	1	1	Nutrients from agricultural use in the catchment	1	1	TOURISM - FISHING	3	1	Tourism	3	3
Sediment from agricultural use in the catchments	1	1	Some farming (e.g. cattle)	1	1	Tourism effluent disposal directly into the ocean untreated	3	1	Tourism pressure	3	1
Accelerated run-off increasing erosion	2	1	Erosion	2	1	tourist	3	1	tourism/ over population in coastal regions	3	1
Natural erosion	2	2	Top soil run-off	2	1	tourists - human waste from boats	3	1	Tourism/Aircraft fuel	3	1
Amateur fisher	3	1	The use of reef damaging sunscreen by tourists on reef.	3	1	Tourists and sunscreen	3	1	tourists	3	2
Commercial and recreational fishers and tourism	3	1	Live trout professional fishermen	3	1	Tourists- contaminating reef with sunscreen	3	1	no stream maintenance	4	1

What are the top two pressures on the health of the Great Barrier Reef?											
1st Round						3rd Round					
	Code	n		Code	n		Code	n		Code	n
International shipping ballast	3	1	Maritime traffic (pollution from container ships)	3	1	Foreign objects in waterways	4	1	Climate change	6	5
Mooring; No solid evidence that reef health is declining	3	1	Overfishing	3	1	Climate	6	2	Global warming	6	4
More ship travel	3	1	Professional fishermen	3	1	climate change	6	3	Global warming - Coral bleaching	6	1
Overfishing	3	2	Recreational fishing activities	3	1	Climate change	6	15	Rising sea temperatures	6	1
Shipping	3	2	Shipping	3	2	Climate Change	6	1	Adverse weather conditions	8	1
Tourism	3	2	Shipping movement - resuspending sediment	3	1	global waarming	6	1	cyclones	8	5
Tourism overpressure	3	2	Shipping with antifouling paints	3	1	global warming	6	1	Cyclones	8	13
Tourism pressure	3	10	Tourism overpressure	3	3	Global warming	6	4	Heavy rainfall	8	1
Tourism/Live trout fishing	3	1	Tourism pressure	3	9	Global Warming	6	2	weather events cyclones and floods	8	1
Drainage - badly managed	4	1	Tourists	3	1	global warming / coral bleaching	6	1	Weather patterns	8	1
Climate change	6	32	Urbanisation/traffic (e.g. boats)	3	1	global warning	6	1	plastic	11	1
Climate change - natural cycle	6	1	Developers	5	1	increasing water temperatures	6	1	Plastic	11	1
Climate change - natural cycles	6	1	Climate change	6	4	Pods of elevated temperature water	6	1	plastics	11	1
Climate change - rising water temperature	6	1	Climate in general	6	1	Sea temperature fluctuations	6	1	Poison	11	1
Climate change - sun and high temperature	6	1	Climatic pressure	6	1	Sea water temperature	6	1	citys	12	1
Climate change - temperature	6	2	El-nino	6	1	warming	6	2	population pressure	12	1
Climate change cycles	6	2	Global warming	6	5	Warming of ocean and water quality	6	1	General pollution	12	1

What are the top two pressures on the health of the Great Barrier Reef?											
1st Round						3rd Round					
	Code	n		Code	n		Code	n		Code	n
Climate change/Global warming	6	1	Global warming; my core is fixing CO2 to reverse global warming	6	1	Warming of water	6	1	human waste	12	1
Climatic variability	6	1	Global warming/Cities/Urban pollution	6	1	water tempurature	6	1	Increased urbanisation	12	1
Global warming	6	16	Increasing water temperature	6	5	cyclones	8	2	people	12	1
Global warming - coral bleaching	6	1	Increasing water temperature/Polluted water	6	1	Cyclones	8	6	people going there	12	1
Global warming from the other side of the world	6	1	Lack of good wet season	6	1	Extreme weather conditions	8	2	Population	12	1
Global warming/Cyclones	6	1	Rising sea temperature	6	2	intensity of wet season	8	1	Population growth along coast	12	1
Increasing temperature	6	1	Temperature rising	6	1	Natural cycles	8	1	Towns	12	1
Increasing water temperature	6	4	Water temperature	6	1	Natural disasters (cyclones)	8	1	Urban development	12	3
Ocean temperature rising	6	1	Coastal erosion from urban run-off rainforest damage	8	1	natural rainforest run-off	8	1	urban developments	12	1
Rising sea temperature	6	1	Currents moving water north	8	1	rainfall and highflow events	8	1	Urban pollution	12	1
Sea level rise	6	1	Cyclones	8	8	pig	9	1	Urban run-off	12	1
Sea surface temperature and coral bleaching	6	1	Cyclones - weather conditions	8	1	No definative data on farm effect	10	1	urbanisation	12	1
Temperature	6	1	Cyclones and natural phenomenon and global warming	8	1	Plastics	11	2	WHAT THE PEOPLE OF SYDNEY PUT INTO THE OCEAN	12	1
Water temperature	6	1	Cyclones and other natural events	8	2	High population on coast adjacent to reef	12	1	Adani	13	1
Cultivation	7	1	Diminishing natural coastal wetlands natures filtration system	8	1	human encroachment	12	1	I think researchers are chasing money by saying there is a problem	13	1

What are the top two pressures on the health of the Great Barrier Reef?											
1st Round						3rd Round					
	Code	n		Code	n		Code	n		Code	n
Cultivation at the wrong time	7	1	Extreme weather	8	1	Humans	12	1	JCU	13	1
Cyclic weather change	8	1	Extreme weather events	8	4	population	12	1	mining	13	1
Cyclones	8	16	Frequent coastal cyclones	8	1	urban development	12	4	DIN	14	1
Cyclones & weather events	8	6	Heavy raifall ever	8	1	urban sprawl	12	1	Nitrate Run-off	14	1
Cyclones and weather	8	1	Heavy rainfall, cyclones	8	1	chemicals may play a part in reef close to the coast	14	1	Nitrogen	14	1
Extreme temperature events/cyclones	8	1	Mother nature is the boss - she has her ways which cannot be controlled	8	1	DIN	14	1	Nitrogen in rainfall: 6 - 8 kg/ha/yr in Innisfil area	14	1
Extreme weather events - cyclones	8	1	Natural cycle	8	1	Fertiliser	14	1	Nutrient and sediment from land use	14	1
Extreme weather events - temperature	8	1	Natural cycle - from nature	8	1	nutrient run-off	14	2	Nutrient run-off	14	1
Lack of rainfall	8	1	Natural cycling of biota	8	1	sediment	14	4	sediment	14	1
Mother nature	8	1	Natural disasters (e.g. cyclones)	8	2	Sediment	14	2	Sediment	14	1
Natural cycle	8	1	Natural discharges in virgin land	8	1	sediment Run-off	14	1	sediment run-off from other land uses	14	1
Natural cycle - Climate change	8	2	Rivers no long have sufficient capacity - more flooding on farms	8	1	water quality from everbody	14	1	Sediment run-offs from major rivers	14	1
Natural events of a catastrophic nature	8	1	To much emphasis is put on GBR this is all natural happens	8	1	Bleaching	15	1	Coral bleaching events	15	1
Nature cycle	8	1	Tree colour and vegetation from urban swamp	8	1	coral bleaching	15	1	COTS	15	1

What are the top two pressures on the health of the Great Barrier Reef?											
1st Round						3rd Round					
	Code	n		Code	n		Code	n		Code	n
On flow form wide ocean	8	1	Water quantity entering GBR lagoon	8	1	COT and natural influences - floods and cyclones	15	1	Crown of thorns	15	4
Weather	8	1	Weather	8	1	Crown of thorns star fish	15	1	crown of thorns starfish	15	1
Weather cycles over different periods of time	8	1	Weather patterns (cyclones, storms)	8	1	I'm not a specialist so I don't know	16	1	Crown of thorns starfish	15	1
Weather patterns	8	1	Feral pigs	9	1	I'm not qualified to answer that	16	1	cycle of bleeching and will repair its self	15	1
Pig damage in shrub and instream	9	1	Feral pigs. Damage on land causing run-off. Poor management of public lands/natinal parks. No filters on urban run-off (e.g. dirt, rubbish etc.)	9	1	Total		118	Ocean Acidification	15	1
Poorly managed national parks (e.g. pig damage)	9	1	Increasing feral pigs in national parks	9	1				Sun causing bleaching	15	1
Wild pigs in national parks	9	1	Pig damage	9	1						
Cities - sewage etc. dishwashing liquid	12	1	Pigs digging up national parks and creek banks	9	1						
Cities and towns (sewage etc.)	12	1	Pigs in rainforest	9	1						
City waste	12	1	Fukishima disater	11	1						
Coastal population	12	1	Chemical waste in urban and rural areas	12	1						
Development, buildings and people	12	1	City waste water	12	1						
Domestic run-off in built up communities	12	1	Coastal pollution growth	12	2						
General numbers of people - increase of population	12	1	Coastal urban development	12	1						

What are the top two pressures on the health of the Great Barrier Reef?											
1st Round						3rd Round					
	Code	n		Code	n		Code	n		Code	n
Human impact	12	3	Development	12	1						
Human impact - tourism	12	1	Domestic sewage	12	1						
Humans	12	1	Dumping of sewage on reef - they all do play part in this equally. A lot of fertilisers/herbicides and pesticides do get used in suburban areas with no restrictions - they do not stay contained on the property applied to, they also end up in drains and waterways and the reef - we all put pressure on the reef	12	1						
Increasing coastal pollution	12	1	Human impact	12	1						
Large cities	12	1	Human population	12	1						
Men-made (Farmers and others) pollutions	12	1	Human pressure	12	1						
Ocean currents bringing sewrage and urban pollutions	12	1	Human pressure on reef	12	1						
Over population	12	2	Humans	12	1						
Population growth on the coast	12	1	Increased urbanisation	12	1						
Population pressure	12	2	Increasing population density	12	1						
Residential development	12	1	Over population of coast	12	2						
Run-off from city & town	12	1	Overuse	12	1						
Run-off from coastal towns	12	1	Pollution	12	1						

What are the top two pressures on the health of the Great Barrier Reef?												
1st Round						3rd Round						
	Code	n		Code	n		Code	n		Code		n
Sewerage system	12	1	Population encrease along the coast	12	1							
Urban development	12	9	Population growth along the East coast of Australia	12	1							
Urban growth - cities and towns	12	1	Population pressure	12	1							
Urban run-off	12	4	Rising coastal populations	12	1							
Urban spread	12	1	Sewage and run-off from greater areas of housing	12	1							
Urbanisation	12	3	Sewage outfall	12	1							
Government regulations	13	1	Sewerage	12	1							
Increased capacity to measure pollutants will show an increase on pollutant level	13	1	Urban	12	1							
People - scientists giving the wrong info	13	1	Urban and rural run-off	12	1							
Political agenda	13	1	Urban development	12	5							
Nutrient, sediment run-off	14	1	Urban pressure	12	1							
Run-off	14	2	Urban run-off	12	4							
Run-off farms all areas that impact river	14	1	Urban/Touliets/Ocean ships	12	1							
Run-off from rivers	14	1	Vehicle emissions, oil etc.	12	1							
Sediment	14	1	Antifouling paint	13	1							
Sediment - all land uses	14	1	Industrial pollution; GBR is a fairly good self maintaining system	13	1							
Sediment run-off	14	1	Management with preset agendas using partial	13	1							

What are the top two pressures on the health of the Great Barrier Reef?										
1st Round						3rd Round				
Code		n	Code		n	Code		n	Code	n
			truth to drive public opinion							
Water quality	14	1	Narrowly defined minority focus groups	13	1					
Acidification	15	1	Politicians	13	1					
Agriculture and nutrient run-off; starfish	15	1	Poor modelling	13	1					
Bleaching	15	1	Sporting venues and Government infrastructure	13	1					
Coral bleaching	15	4	All mainland run-off	14	1					
Coral bleaching - high water temperature	15	1	Chemicals	14	1					
Crown-of-thorns starfish	15	2	Direct pollutions	14	1					
Natural pressures (e.g. crown of thorns)	15	1	Farms, national parks, urban areas	14	1					
Don't know	16	1	Minimise sediment run-off	14	1					
Don't know due to lack of evidence	16	1	Nitrogen issues	14	2					
Not sure	16	1	Nutrient	14	1					
			Nutrients	14	1					
			Often Pollutions	14	1					
			Pesticide - CONFIDOR	14	1					
			Rate of run-off	14	1					
			Run-off	14	1					
			Sediment	14	2					
			Sediment from cattle	14	1					
			Sediment run-off	14	4					
			Water quality	14	4					

What are the top two pressures on the health of the Great Barrier Reef?											
1st Round						3rd Round					
Code		n	Code		n	Code		n	Code		n
			Bleaching	15	2						
			Bleaching from climate change	15	1						
			Crown-of-thorns starfish	15	1 2						
			Ocean acidification, cyclones	15	1						
			Don't know	16	1						

APPENDIX 8: TOP CAUSES OF POOR WATER QUALITY IN LOCAL STREAMS, RIVERS AND WATERWAYS, ANECDOTAL COMMENTS FROM BURDEKIN LAND MANAGERS (CANE), CODED

Code	Theme
1	Farming (Banana, Cane, Grazing and Fruit Growing)
2	Run-off
3	Weather/Natural Run-off/Floods/Rainfall
4	No poor water quality/Reef Healthy
5	Weeds
6	Urban Development
8	Feral Animals (Pigs)
9	Other Industry, Shipping, Mining or Government
11	Blockages in creeks, clearing creeks and drains
12	Erosion
15	Bare ground
16	Salinity/Calcium
17	Don't know

First Round - Top Cause 1	Code	n	Third Round - Top Cause 1	Code	n
Applied herbicides	1	1	bad fertiliser practises	1	1
cattle country	1	1	chemical run-off	1	1
Excessive chemical usage	1	1	from irrigation going directly into channels	1	1
FARMERS WHOSE RUN-OFF WATER RUNS INTO WATER WAYS	1	1	minority group of farmers use excessive use of N and chemicals	1	1
fertilizer run-off over application	1	1	Nutrient	1	1
Green cane trash	1	1	Nutrient Run-off	1	1
nitrogen	1	1	Nutrient, chemical and sediment run-off	1	1
Old school farmers who put fertiliser on right before it rains	1	1	other irrigators; Barrata system;	1	1
People using chemical in excess - poor application. They put it on and then it rains.	1	1	Poor agricultural practices-they cannot measure run-off	1	1
people who cut 'green' and don't burn, the water goes stagnant	1	1	Spraying weeds	1	1
poor ground cover management	1	1	Trash blankets	1	1
Run-off from grazing	1	1	water quality is good could always be better most run-off is inland from cane farms no farms in the burdekin run into the river all water runs away from the river	1	1
The small percentage of bad farmers with bad farming practices	1	1	black water from wetland areas-high vegetation growth	3	1
deoxygenation	2	1	Climate - rainfall interacting with land management practices	3	1

First Round - Top Cause 1	Code	n	Third Round - Top Cause 1	Code	n
It from Rain events that is out of my control.	3	1	heavy rains, irrigation doesn't move much	3	1
leahing	3	1	rainfall	3	1
No rain.	3	1	run-off after rain events	3	1
Poor govt policies re water pricing systems in the Burdekin irrigation area	4	1	soil erosion from water Run-off and rain. Look at the waterways for centuries when you see the water from rivers running out to the sea they are brown this has always happened.	6	1
i dont think there is as poor quality in our creek systems that is lead to believe. i have lived hear for 48 years and have seen a lot of changes in the barratta creek from 20 years ago when you had a dead system that you could not fish out of to now where it is vibrant and fish stocks are good and clean	8	1	all local waterways are healthy	8	1
in some circumstance it improves	8	1	water quality is good, some mud but not much run-off	8	1
We have good water in this area	8	1	Run-off	12	1
Don't know. Sewage. Big floods.	11	1	Sediment	12	1
urban run-off	11	1	Sediment runnoff from inland areas	12	1
Nutrient and sediment run-off. Burdekin less so than other areas.	12	1	water waste	12	1
Run-off from local bush	12	1	100% channel water is used in my farm and the channel quality is poorer than that of river. Don't know the exact reason.	15	1
run-off from other farms	12	1	A continuous flowing channel through the farm is turned off. the difference in water levels creates fish/turtle kills	15	1
salts in water	12	1	Area prone to salt	15	1
Sediment	12	1	High calcium on some properties	15	1
Sediment run-off	12	1	naturally alkaline has to mix with salty water	15	1
turbitity	12	1	salinity	15	2
no idea	17	1	salt intrusion	15	1
Unknown	17	1	Aquatic weeds	16	1
rotting vegetation	16	1	decaying plants ie water weeds, grasses	16	1
Water weeds	16	1	Dying vegetation(overgrown weeds & grass) in wet season	16	1
weeds	16	1	Introduced fish species and introduced weeds	16	1
What is classed as Poor Water Quality?		1	Introduced weeds	16	1
Total		36	Weeds	16	1
a. Round = First Round			Weeds and grasses	16	1
			NO IDEA	17	1
			none		1
			unable to answer		1
			Total		42
			a. Round = Third Round		
First Round - Second Top Cause 1	**Code**	**n**	**Third Round - Second Top Cause 1**	**Code**	**n**
chemical	1	1	farm run-off	1	1

First Round - Top Cause 1	Code	n	Third Round - Top Cause 1	Code	n
chemicals	1	1	Inefficient Irrigation practices	1	1
nitrates in water	1	1	nutrient run-off	1	1
Nutrients	1	1	Pesticide Run-off	1	1
other farmers	1	1	Pesticide/ old chemicals	1	1
dirty water from river	3	1	lack off rain	3	1
Storms causing overflow	3	1	leaching	3	1
mining industry	4	1	Rain events	3	1
Run-off from urban and commercial areas	11	1	goverment	4	1
black water events	12	1	poor drainage	5	1
Inland properties that are sometimes poorly managed and Natural cycles of drought	12	1	Poor land managment	5	1
poor weed control	16	1	Unseasonal heavey rain on dry bare soil combined with minimal recycle pits I've got them but I'm in the minority.	9	1
Total		12	Sewage pumped into our oceans 'deliberately'. Our society will be judged on this ignorant practise.	11	1
a. Round = First Round			sediment Run-off from grazing and urban use	12	1
			Salt on some properties	15	1
			Decaying vegetation?	16	1
			Weeds	16	1
			unsure	17	1
			Unsure	17	1
			Trawlers		1
			Total		20
			a. Round = Third Round		

APPENDIX 9: TOP PRESSURES ON THE HEALTH OF THE GREAT BARRIER REEF, ANECDOTAL COMMENTS FROM BURDEKIN LAND MANAGERS (CANE), CODED

Code	Theme
1	Climate Change/Global Warming
2	Weather/Natural Run-off/Floods/Rainfall
3	Run-off
4	Fishing/Shipping/Tourism
5	Urban Development
6	Farming (Banana, Cane, grazing and Fruit Growers)
7	Acidification/CoT/Coral Bleaching
8	Feral Animals (Pigs)
9	Other Industry, Mining, Government, Research
10	No poor water quality
11	Illegal dumping/Accidental Spills/Pollution
12	Erosion
13	Cultivation Practices
14	Blockages in creeks, cleaning creeks and drains
15	Construction/Civil Works
16	Don't know

What are the top two pressures on the health of the Great Barrier Reef?					
First Round - Top Pressure	**Code**	**n**	**Third Round - Top Pressure**	**Code**	**n**
climate change	1	1	climate	1	1
Climate Change	1	1	climate change	1	1
climate change and rising temperatures	1	1	Climate change	1	2
global warming	1	2	Climate Change	1	1
sea temperatures	1	1	CLIMATE CHANGE	1	1
Water temperature	1	1	Climate change I believe	1	1
water temperatures	1	1	Climate Change, increasing sea temp and acidification, coral bleaching	1	1
Humans in general, not just farmers. Farmers just have a bigger footprint on the land.	2	1	global warming	1	2
All cities on the coast put pressure on the reef the Run-off of rain water has a high nitrogen rate and grazers land.	2	1	Global warming	1	1
urban, cities. pollution	2	1	higher temperatures	1	1
Natural changes	3	1	Rising Ocean Temperatures	1	1
Seasons - e.g. high temperatures. Natural changes. Global warming isn't real.	3	1	city sewerage discharge	2	1

What are the top two pressures on the health of the Great Barrier Reef?					
First Round - Top Pressure	**Code**	**n**	**Third Round - Top Pressure**	**Code**	**n**
Weather e.g. cyclones, shipping accidents, grazing and mining	3	1	Concentrated populations along the coast-heavy metals are not controlled	2	1
weather events	3	1	Urbanisation	2	1
Weather patterns	3	1	River from excessive rainfall from out west	3	1
shipping	4	1	weather cycle	3	1
fishing	4	1	over fished	4	1
tourism	4	1	Over fishing from professionals	4	1
Tourism	4	1	Tourism	4	1
Crown of thorns.	5	1	We don't manage fishing stocks correctly - fishing waters should be managed like a farm and it would be a lot better.	4	1
Thorn fish	5	1	sun bleaching	5	1
cattle country being left bare and overgrazed causing sediment run-off	6	1	farm run-off from all farms unregulated farms	6	1
existing traditional land use practices	6	1	sediment Run-off from grazing	6	1
nitrogen	6	1	There are cowboy farmers out there	6	1
Run-off from grazing and urban develpoments	7	1	Silt and rubbish after a flood	7	1
run-off from all not eastern coast not just mackay north	7	1	silt coming down rivers, urban sewerage	7	1
sediment	7	1	Turbid water	7	1
Sediment	7	1	Mining Run-off	10	1
Sediment and nutrient run-off	7	1	Politicians	10	1
Pigs in the rainforest	9	1	Continuing funding for research sector-neg & positive	10	1
Coal mines	10	1	Data accuracy and Honesty	10	1
I think it's healthy - it's still growing.	13	1	researchers trying to keep their jobs	10	1
Oil spill	14	1	All pollution sewage, plastic, soil, all chemicals through farming, and cleaning of any kind	14	1
no idea	16	1	pollution from cities	14	1
HAVE NO OPINION		1	Pollution from cities/town	14	1
Total		36	pollution from the cities	14	1
a. Round = First Round			don't know	16	1
			Unsure	16	2
			I am not a reef scientist		1
			Total		42
			a. Round = Third Round		

First Round - Second top pressure	Code	n	Third Round - Second top pressure	Code	n
climate change	1	1	climate change	1	1
Climate Change	1	1	global warming	1	1

climate change caused by energy hungry cities	1	1	Effluent from large cities	2	1
Environmental changes	1	1	Human activity that leads to increased Run-off. either urban or agricultural.	2	1
global warming	1	1	Human impacts that affect the ability of the reef to bounce back from bleaching. Also the fact that nutrients may be causing crown of thorns outbreaks more than would otherwise occur. I'm only going on what I've heard, I'm not a scientist. Everything we do as humans affects our environment.	2	1
Global warming	1	1	Man-made activities on land and off shore	2	1
Water temperature	1	1	non-farm public and politicians who believe them	2	1
water temperature	1	1	people	2	1
Humans	2	1	Population having access to concentrated chemicals with no MSDS sheets or awareness	2	1
Run-off from cities	2	1	Untreated sewerage	2	1
Sewage from cities.	2	1	urban development ie drains from roadways	2	1
urban effluent	2	1	cyclones	3	2
Big cyclone.	3	1	Cyclones	3	1
Cyclones	3	1	after heavy rain overflow from sewerage	3	1
extreme weather events	3	1	Bag limits should be reduced and fish sizes should be reconsidered as well.	4	1
seasonal variability	3	1	Commercial fishing	4	1
Crown of thorns.	5	1	tourism	4	2
cattle farmers	6	1	natural causes-crown of thorns, cyclones	5	1
chemical	6	1	banana farmers run-off	6	1
use of hormones on cattle production	6	1	farming/natural disasters	6	1
sediment run-off	7	1	lack of monitoring skills of farmers	6	1
stream Run-off	7	1	nitrogen	6	1
Communists and Labor party because they refuse to put money towards it.	10	1	run-off form farms	7	1
mining industry	10	1	Run-off from land	7	1
ports	10	1	Sediment	7	1
cultivation of soil, application of inorganic fertiliser, herbicide/insecticide	11	1	unwanted sediments	7	1
The Ecosystem		1	erosion from upstream	8	1
Total		27	Researchers persistent pointing of the blame to 'only one cause'	10	1
a. Round = First Round			Depending on who you listen to but I think the reef is doing ok	13	1
			pollution	14	1

			Pollution from cities on the coast and rain cycles.	14	1
			Population growth in adjacent areas	14	1
			Unsure	16	2
			Total		36
			a. Round = Third Round		

APPENDIX 10: TOP CAUSES OF POOR WATER QUALITY IN LOCAL STREAMS, RIVERS AND WATERWAYS, ANECDOTAL COMMENTS FROM BURDEKIN GRAZING LAND MANAGERS, CODED

Code	Theme
1	Chemicals/contamination
2	Don't Know/Other
3	Drought
4	Erosion/sediment
5	Excessive use of fire
6	Feral animals
7	Government/Legislation/Policy
8	Heavy rainfall or extreme weather
9	Lack of rain or irregular water flow
10	Main roads
11	Mining
12	No ground cover
13	No poor water quality
14	Pollution and or rubbish
15	Poor cane farming practices
16	Poor land management
17	Poor soil
18	Poor grazing practices
19	Run-off
20	Urban development
21	Vegetation/weed management

What are the top causes of poor water quality in your local streams, rivers & waterways?							
Cause 1		**1st**	**3rd**	**Cause 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
Contamination	1	1		High nutrient levels	1	1	
Lime in the water	1	1		Chemicals	1	2	
Salt intrusion	2	1		We are end of the line so extensive accumulation prior to reaching us	2	1	
Drought	3	1		Drought	3	1	
dry weather	3	1		Lack of rain	3	1	
waterways have hardly run in the last 4 years	3	1		Lack of rainfall	3	1	
erosion	4	1		Low rainfall	3	1	
Gully erosion that is difficult to control	4	1		erosion upstream	4	1	
soil erosion	4	1		Erosion	4	1	
TOO MUCH SOIL RUN-OFF	4	1		Erosion	4	2	
Sediment run-off	4	1		The abolition of the Two Chain Law in the 1960s/70s. Chain is 22 yards. Protection of the banks of creeks, was abolished.	7	1	
Sediment	4	2		Cyclone damage	8	1	
excessive use of fire	5	1		Heavy rain prior to land revegetating	9	1	
Pigs	6	1		Fast moving water	8	1	
Floods	8	1		heavy rains after dry	8	1	
Irregular water flow as controlled upstream	9	1		Heavy rainfall events after prolonged dry times	8	1	
Lack of wet - nothing to flush the system	9	1		no clean streams	9	1	
low flows	9	1		Coal mines	11	1	
no rainfall to cause running water	9	1		Overgrazing of riparian zones (river and creek frontages)	16	1	
lack of rain	9	2		Lack of ground cover	12	2	
Unsealed Council road through my property	10	1		rubbish from recreational campers up stream	14	1	
I don’t think it is an issue in this area	13	1		poor cane farming practices (kill soil, bare soil, high artificial inputs, monoculture, no grazing animal impact)	15	1	

What are the top causes of poor water quality in your local streams, rivers & waterways?							
Cause 1		**1st**	**3rd**	**Cause 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
Mining and ground cover	11	2		using fire every year	16	1	
Lack of ground cover	12	1		Property managers working the country too hard	16	1	
low ground cover	12	1		mono cultures - lack of ground cover - woody weed infestations - local government failing to implicit tech in road maintenance	16	1	
Properties with no ground cover	12	1		poor landscape management	16	1	
Don't have poor water quality	13	1		cattle eroding stream banks	16	1	
good quality water in my area, dirt in system after rain	13	1		continuous grazing and the extreme patches resulting from(outside the fence again)	16	1	
We are at the head of the river system - our springs etc. are of the highest water quality when they leave our property. There is no chemical run-off from our land as we don't spray our forage crops	13	1		Poor grazing management: Over-grazing of palatable plants reducing soil cover, combined with UNDER-grazing of less-palatable plants leading to moribund plants &/or too much fire.	16	1	
Pollution	14	2		Invasive weeds and pests. As well as the underutilisation of regrowth control methods, including blade-ploughing.	21	1	
Sodic soil	17	1		rotting vegetation	21	1	
Soil	17	1		Tree and shrub cover reducing grassland body and health.	21	1	
suspended clay	17	1		weeds along waterway	21	1	
poor farming/grazing practices,	18	1		Ag chemicals, lack of ground cover and topsoil stability	1		1
Bank erosion from cattle and clearing	18	1		Lack of water	3		1
lack of rotation of stock	18	1		erosion	4		4
over estimating the seasonal carrying capacity(outside our boundary)	18	1		erosion of ground cover	4		1
over grazing	18	1		Erosion, cattle watering directly in water sources and over stocking	4		1
Over grazing	18	1		Seasonal influence	4		1

What are the top causes of poor water quality in your local streams, rivers & waterways?							
Cause 1		**1st**	**3rd**	**Cause 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
Overgrazing	18	1		Seasonal Rainfall	6		1
People who over graze & road ways	18	1		Feral pigs, flooding rains - natural takes tonnes of sediment with it.	6		1
all good - except for noxious weed problem	21	1		Flying fox colonies	8		1
Rubber vine	21	1		Creek starts running dry and fills with other crap. Some flooding = some soil.	8		1
Weed infestation and rubber vine	21	1		Stagnant water	9		1
weeds from up stream	21	1		Main Roads in Townsville, should put in sediment trap on either side of the road. Increases velocity of water which creates a gully which then runs sediment into the creek. Areas with no vegetation, hardened pan, highly erodible, they're natural but we should be doing something about it.	9		1
Woody weed Infestation	21	1		Mine water release.	10		1
leaves	21	1		From topsoil being removed from areas upstream to area downstream which effects water flow - where does it all end up!	11		1
Too much remnant vegetation	21	1		Poor ground cover	12		1
Accumulating chemicals	1		1	Poor Ground Cover	12		1
sa	1		1	rubbish along roads and beaches	12		1
Don't know	2		1	Neighbours	14		1
Drought, No rain	2		3	Poor farming practices	16		1
Not in a poor way, just no water in them due to drought	3		1	Poor livestock and pasture management	16		1
They've been the way they are for as long as I can remember	3		1	old roads tracks	16		1
Dissolving soils and eroding land	3		1	Sodic soils	16		1
EROSION	4		1	Run-off	17		1
Stream bank erosion	4		1	sediment	18		1

What are the top causes of poor water quality in your local streams, rivers & waterways?							
Cause 1		**1st**	**3rd**	**Cause 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
Erosion	4		1	Over grazing	18		1
Sediment control	4		5	overgrazing	18		1
fence lines	4		1	Overstocking	18		1
Feral animals	6		1	People upstream who have overgrazed paddocks.	18		1
Pigs, cattle erosion	6		1	Stocking rates	19		1
Extreme weather events	8		1	Residential run-off	20		1
Heavy rain on bare paddocks.	8		1	Sewage from our city's. Overgrazing of land, bad land management	20		1
long dry spells and heavy rainfall	8		1	Accumulating weed seeds	21		1
The speed of the Run-off after big rain.	8		1	clearing with dozers to remove weeds	21		1
very dry and hard country with heavy first rains with allot of top soil Run-off	8		1	excessive vegetation growth	21		1
Lack of decent flow due to rain fall	9		1	Virgin retention areas - because there is low established ground cover	21		1
Lack of water infiltration, when water picks up speed it picks up soil particles and takes it with it. slow the water down, so it soaks in.	9		1	Weeds from neighbours	21		1
Rainfall intensity	9		1	as			
don't run long enough - not permanent	9		1			36	39
Hardly any water in them, only when it rains and its fine.	9		1				
Comes from stirring up stagnant water. The water clears up when it's been running for a while.	9		1				
Lack of rain - Stagnation	9		1				
Lack of rain	9		2				
Main Roads - Every KM of road has 150ml of material, within 9 years it's lost. 2.5 tonne per lineal metre therefore 2,500 tonnes per km replaced every 5-9 years. Actively eroding	10		1				

What are the top causes of poor water quality in your local streams, rivers & waterways?							
Cause 1		**1st**	**3rd**	**Cause 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
every day. Main Roads in Townsville, should put in sediment trap on either side of the road. Increases velocity of water which creates a gully which then runs sediment into the creek.							
Coal mine pit pump outs erosion on public roads caused by poor design and lack of education	11		1				
Coal Mines	11		1				
Mining/Industry	11		1				
Native vegetation regrowth - because it minimised the ground cover	12		1				
lack of ground cover (which has nothing to do with 'stocking rate'	12		1				
Lack of groundcover due to thickening of regrowth timber and the inability to manage remnant vegetation.	12		1				
Poor ground cover	12		2				
Fine - Crystal Clear after a decent wet	13		1				
Isn’t any	13		1				
No poor water quality	13		1				
No water quality issues to discuss	13		1				
Our water is beautiful up here, runs over basalt. 70 mil gallons a day one of the springs runs.	13		1				
Our water systems have good water quality and minimal sediment loss due to improved pasture	13		1				
Our waterways are in good condition	13		1				
Water quality here is beautiful	13		1				
We are at the head of the catchment, it's pristine.	13		1				

What are the top causes of poor water quality in your local streams, rivers & waterways?							
Cause 1		**1st**	**3rd**	**Cause 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
Cane farm Run-off	15		1				
Gross overstocking	16		1				
Over-burning /overgrazing	16		1				
overgrazing	16		1				
overstocking	18		1				
Overstocking	18		1				
Poor land management	18		1				
Shallow depth	18		1				
Run-off from poorly pastured properties	18		1				
Run-off from graziers, mines and farms	19		1				
urban development, vehicle oil spills,	20		1				
Excessive lantana growth in streams	21		1				
Noxious Weeds, Over Grazing	21		1				
Weed Control - Spreading of weeds from land that isn't maintained.	21		1				
vegetation management	21		1				
weeds	21		1				
Weeds and animal pests	21		1				
increasing stem density from woody weeds and vegetation	21		1				
		52	70				

APPENDIX 11: TOP PRESSURES ON THE HEALTH OF THE GREAT BARRIER REEF, ANECDOTAL COMMENTS FROM BURDEKIN GRAZING LAND MANAGERS, CODED

Code	Theme
1	Australian Defence Force
2	Chemical Run-off
3	Land clearing/Erosion/Lack of ground cover
4	Climate Change/Global Warming
5	Coral Bleaching/Crown of Thorns
6	Don't know/Unsure
7	Government
8	Inconsistent messages/knowledge
9	Mining
10	Natural Process
11	Other farming (not cane or grazing)
12	Pests/Weeds
13	Sediment
14	Shipping/Boating Damage
15	Tourism
16	United Nations/Greens Groups
17	Urban Development/Pollution
18	Weather Events
19	Nutrient Run-off
20	Other Run-off
21	Greenies/Do gooders
22	Sustainability
23	Recreational/Commercial Fishing
24	Lack of financial support
25	Minority Land Holders

What are the top two pressures on the health of the Great Barrier Reef?							
Pressure 1		**1st**	**3rd**	**Pressure 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
Contamination	1	1		High nutrient levels	1	1	
Lime in the water	1	1		Chemicals	1	2	
Salt intrusion	2	1		We are end of the line so extensive accumulation prior to reaching us	2	1	
Drought	3	1		Drought	3	1	
dry weather	3	1		Lack of rain	3	1	

What are the top two pressures on the health of the Great Barrier Reef?							
Pressure 1		**1st**	**3rd**	**Pressure 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
waterways have hardly run in the last 4 years	3	1		Lack of rainfall	3	1	
erosion	4	1		Low rainfall	3	1	
Gully erosion that is difficult to control	4	1		erosion upstream	4	1	
soil erosion	4	1		Erosion	4	1	
TOO MUCH SOIL RUN-OFF	4	1		Erosion	4	2	
Sediment run-off	4	1		The abolition of the Two Chain Law in the 1960s/70s. Chain is 22 yards. Protection of the banks of creeks, was abolished.	7	1	
Sediment	4	2		Cyclone damage	8	1	
excessive use of fire	5	1		Heavy rain prior to land revegetating	9	1	
Pigs	6	1		Fast moving water	8	1	
Floods	8	1		heavy rains after dry	8	1	
Irregular water flow as controlled upstream	9	1		Heavy rainfall events after prolonged dry times	8	1	
Lack of wet - nothing to flush the system	9	1		no clean streams	9	1	
low flows	9	1		Coal mines	11	1	
no rainfall to cause running water	9	1		Overgrazing of riparian zones (river and creek frontages)	16	1	
lack of rain	9	2		Lack of ground cover	12	2	
Unsealed Council road through my property	10	1		rubbish from recreational campers up stream	14	1	
I don’t think it is an issue in this area	13	1		poor cane farming practices (kill soil, bare soil, high artificial inputs, monoculture, no grazing animal impact)	15	1	
Mining and ground cover	11	2		using fire every year	16	1	
Lack of ground cover	12	1		Property managers working the country too hard	16	1	
low ground cover	12	1		mono cultures - lack of ground cover - woody weed infestations - local government failing to implicit tech in road maintenance	16	1	
Properties with no ground cover	12	1		poor landscape management	16	1	
Don't have poor water quality	13	1		cattle eroding stream banks	16	1	
good quality water in my area, dirt in system after rain	13	1		continuous grazing and the extreme patches resulting from(outside the fence again)	16	1	

What are the top two pressures on the health of the Great Barrier Reef?							
Pressure 1		**1st**	**3rd**	**Pressure 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
We are at the head of the river system - our springs etc. are of the highest water quality when they leave our property. There is no chemical run-off from our land as we don't spray our forage crops	13	1		Poor grazing management: Over-grazing of palatable plants reducing soil cover, combined with UNDER-grazing of less-palatable plants leading to moribund plants &/or too much fire.	16	1	
Pollution	14	2		Invasive weeds and pests. As well as the underutilisation of regrowth control methods, including blade-ploughing.	21	1	
Sodic soil	17	1		rotting vegetation	21	1	
Soil	17	1		Tree and shrub cover reducing grassland body and health.	21	1	
suspended clay	17	1		weeds along waterway	21	1	
poor farming/grazing practices,	18	1		Ag chemicals, lack of ground cover and topsoil stability	1		1
Bank erosion from cattle and clearing	18	1		Lack of water	3		1
lack of rotation of stock	18	1		erosion	4		4
over estimating the seasonal carrying capacity(outside our boundary)	18	1		erosion of ground cover	4		1
over grazing	18	1		Erosion, cattle watering directly in water sources and over stocking	4		1
Over grazing	18	1		Seasonal influence	4		1
Overgrazing	18	1		Seasonal Rainfall	6		1
People who over graze & road ways	18	1		Feral pigs, flooding rains - natural takes tonnes of sediment with it.	6		1
all good - except for noxious weed problem	21	1		Flying fox colonies	8		1
Rubber vine	21	1		Creek starts running dry and fills with other crap. Some flooding = some soil.	8		1
Weed infestation and rubber vine	21	1		Stagnant water	9		1
chemical Run-off from urban development	2	1		ADF	1	1	
CHEMICAL, FERTILIZER, HUMAN	2	1		Chemical run-off. urban, mining and ag	2	1	
Chemicals	2	1		Chemicals Run-off from town water	2	1	
Chemicals - crops	2	1		Land clearing, road grading, mixed agriculture, cane farming	3	1	

What are the top two pressures on the health of the Great Barrier Reef?							
Pressure 1		**1st**	**3rd**	**Pressure 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
chemicals - pharmaceuticals/artificially manufactures substances,	2	1		Climate	4	1	
Chemicals in everyday items used in the towns whose waste water goes to the reef. Cosmetics, fertilizers for gardens etc	2	1		climate change	4	2	
Na	2	1		Climate change	4	1	
Phosphates	2	1		Climate change, cyclones	4	1	
Round up and poisons sprayed by councils to clear drains	2	1		Extremely hot temperatures (bleaching)	4	1	
Water quality from chemical and topsoil run-off	2	1		Rising sea temperatures	4	1	
climate change	4	1		Rising sea temps	4	1	
Climate change	4	2		Sea temperature	4	1	
global warming	4	1		Coral Bleaching (but I'm getting off the media which is probably not right anyway)	5	1	
ocean temperatures	4	1		Crown of thorns star fish	5	1	
Rising temperature	4	1		Own environmental issues i.e. crown of thorns starfish we know that there are lots of factors but none are concrete. We don't know that fertiliser or sediment are the only cause.	5	1	
Sea temperature effects on coral bleaching	4	1		Don't know	6	1	
Sea temperature increase	4	1		I don't know	6	1	
temperature	4	1		I don’t know	6	1	
Crown of thorns	5	1		Not sure - Not a scientist.	6	1	
nature- crown of thorns, cyclones	5	1		Not sure maybe mining or cropping	6	1	
Don't know	6	1		STILL MAKING MY OPINION	6	1	
Unsure/ not qualified to answer	6	1		lack of education	8	1	
which one do we believe	6	1		Coal Dust	9	1	
Government parties and there opinion towards rural industry	7	1		coal ships - oil spills	9	1	
A lot of the information is an inconsistent load of rubbish	8	1		Mining	9	1	
lack of knowledge	8	1		Natural process of growth and decline	10	1	
Grazing & agriculture (clearing)	3	1		Seasons	10	1	
Mining	9	1		Large Dam on the river stopping the silt and	13	1	

What are the top two pressures on the health of the Great Barrier Reef?							
Pressure 1		**1st**	**3rd**	**Pressure 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
				sediment feeding the GBR			
natural growth and decline	10	1		Led to believe that it is sediment - I would imagine that the sediment that enters the reef would have some impact but the sediment would benefit in the long run. I wonder how the reef can survive nutrient wise if it didn't have the rivers to feed it	13	1	
nature	10	1		Sediment	13	4	
Seasonal changes	10	1		Sediment from farming and urban areas	13	1	
Coastal horticulture	11	1		Sediment Run-off	13	2	
I have doubts that there is an issue with the GBR, resources are being wasted here rather than looking into major environmental issues on land such as pests and weeds.	12	1		sediment run-off	13	1	
Sediment	13	1		Shipping	14	1	
Sediment run-off	13	1		Pollution - Rubbish	17	1	
Sediment/Run-off	13	1		Cities by the coast-high population areas-high nitrogen level discharge from urban areas into ocean.	17	1	
siltation	13	1		city and town pollution	17	1	
Soil run-off	13	1		Coastal development	17	1	
anchor damage	14	1		Human Impact - High density population and urban development	17	1	
tourism	15	1		Humans - Coastal Development	17	1	
Tourism	15	1		Pollution around towns and cities e.g. The excess of herbicides/insecticides/detergents to control grasses around waterways (I have seen this MANY times) etc. This would be easy to assess with monitoring stations both up AND downstream of cities and towns along river systems. The monitoring of the TYPE of sediment would also indicate where the sediment had	17	1	

What are the top two pressures on the health of the Great Barrier Reef?							
Pressure 1		**1st**	**3rd**	**Pressure 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
				originated from e.g. Overland flow OR soil types from much deeper sources e.g. Mine pits.			
United Nations and green groups	16	1		Pollution from the cities and towns situated along the coast, especially from sewage treatment plants	17	1	
Pollution	17	1		Residential rubbish, vehicles, tyres, rubbish on beaches, changed waterways in the towns how they hit the ocean, sediment control etc.	17	1	
Coastal communities who are not subject to the rules and regulations regarding domestic chemicals	17	1		Residential/city dwellers	17	1	
population cities along the coast	17	1		run-off from urban areas	17	1	
Rubbish from cities	17	1		Urban development	17	1	
Run-off from Cities, hobby farms, backyards, crop farms & industrial activities closer to the shore.	17	1		Urban development / sewerage	17	1	
Run-off of chemicals from cities and towns close to the reef	17	1		Urban Impact	17	1	
Towns	17	1		urban pollution	17	1	
Urban pollution and Run-off	17	1		Urban Run-off	17	1	
Cyclones	18	2		Caused by cyclones	18	1	
agriculture chemicals	2		1	Cyclone damage	18	1	
Fertilizer/chemicals	2		1	heavy rains when allot of top soil runs down the rivers out to sea	18	1	
Na	2		1	Impacts from cyclones	18	1	
Some farming chemicals (Growers) Grazing has the buck passed on to them as they are an easy target	2		1	Natural Disasters (i.e. cyclones and large floods creating plumes)	18	1	
Climate Change	4		1	Unpredictable Weather	18	1	
Climate change, of which poor grazing land management is one of many causes.	4		1	Soil run-off, from rural, government and resource sector	20	1	
climate variability	4		1	Water quality	20	1	
Coastal development. and sewerage water from urban areas, Inc. Townsville Mackay Yeppoon	4		1	Green groups	21	1	
Global warming	4		1	Greenies, it's been like that for centuries	21	1	
global warming	4		1	Sustainability	22	1	

What are the top two pressures on the health of the Great Barrier Reef?							
Pressure 1		**1st**	**3rd**	**Pressure 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
Crown of thorns	5		1	Closed fishing areas	23	1	
We are told run-off??? Not sure	6		1	fishing (commercial and recreational)	23	1	
Who does know?	6		1	illegal over fishing	23	1	
Unsure/ not qualified to answer	6		1	Outboard fuel vapours	23	1	
Bureaucrat	7		1	afd	1		1
Government and bureaucrats	7		1	Chemical residue	2		1
Ignorant politicians who have absolutely no idea on how the sustainable grazing industry works and haven't got the guts to monitor "big industries" such as mining industries. Easier to pick on the graziers as they don't have the money to fight them and their idiotic policies.	7		1	Chemical Run-off	2		1
Negative media coverage based on misleading percentages	8		1	Chemical run-off ; rural, urban and resource sector	2		1
contaminated water from mine sites	9		1	chemical usage in home gardens	2		1
Mining (graziers are being blamed for sediment run-off which has happened for years).	9		1	Chemical waste and plastic pollution	2		1
Mining, more unrestrained than grazing, less restrictions	9		1	Chemicals	2		2
Natural changes/cycle	10		1	Chemicals in cane farming, Urban Development,	2		1
naturally occurring events	10		1	Chemicals?	2		1
Nature - cyclones	10		1	Closely settled country close to coast little hobby farms, Run-off from those chemicals	2		1
Nutrient run-off	19		2	Led to believe that it is chemical	2		1
Farmers near the coast - NOT CATTLE GRAZIERS IN CW QLD	11		1	Topsoil instability and erosion	3		1
unclean water	20		1	Ground cover	3		1
Increased boats and decline in marine life	23		1	Increasing temperatures	4		1
over fishing	23		1	Temperature of the water	4		1
Sediment and nutrient from floods	13		1	Natural bleaching	5		1
sediment and nutrient run-off	13		1	Mining	9		2
Sediment run-off	13		1	Mining / Farming	9		1
Sediment/nutrient	13		1	Mining and dredging	9		1

What are the top two pressures on the health of the Great Barrier Reef?							
Pressure 1		**1st**	**3rd**	**Pressure 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
Topsoil/sediment from poor farming practices	13		1	Poor mining practices	9		1
tourism	15		1	Scientists with half arse theories who don't know shit from clay	8		1
Large Cities	17		1	environmental changes	10		1
People in the large cities	17		1	Natural Causes	10		1
people pollution	17		1	Natural degradation, tourism	10		1
pollution running off from city streets	17		1	natural disasters	10		1
urban development and pollution	17		1	Not too sure how much pressure is really on. Sometimes we get a bit neurotic about what's going on. Nature is what happens in one big cycle. In terms of geological time I think it's probably fine. We're talking about things that are happening.	10		1
Cyclone damage	18		1	Farming plays a role	11		1
cyclones and recreational fishing	18		1	Pollution, farming - but nothing has been proven	11		1
extreme weather events	18		1	Because there is no sediment the uv rays bleach the coral	13		1
flooded mine sites, large developments and dredging, chemicals	18		1	Sediment and nutrient run-off	13		1
				sediment run-off from agricultural land	13		1
				sediment run-off	13		1
				Shipping pollution	14		1
				Tourist boats / sewerage/ anchor damage	14		1
				tourism	15		1
				tourists - leaving rubbish	15		1
				City effluents	17		1
				City pollutions	17		1
				General waste from town and cities. Urban gardeners using pesticides with no training or regulations.	17		1
				Human Impact in general	17		1
				Nutrient run-off from city & farms	17		1
				pollution from urban drains	17		1
				pollution run-off from urban areas	17		1

What are the top two pressures on the health of the Great Barrier Reef?							
Pressure 1		**1st**	**3rd**	**Pressure 2**		**1st**	**3rd**
Anecdotal Comment	**Code**	**n**	**n**	**Anecdotal Comment**	**Code**	**n**	**n**
				Population and coastal development	17		1
				towns (lawn Fert, chem, washing powder, cleaning products, pesticides, manufacturing, rubbish dumps, fuel, oil, rubber of roads, tourists boats snorkelling rubbish,	17		1
				Urban areas don't have anywhere near the restrictions that farmers do in regards to what they're allowed to use on their gardens and roads and they get more rain and flooding. Impact from urbanisation more than anything.	17		1
				Urban consumers	17		1
				Urban development, mining activity, creek diversions, loss of vegetation and water infiltrations, increased run-off because of loss of mature vegetation deep rooted tree	17		1
				Urban Expansion	17		1
				Nutrient rich water	19		1
				Run-off	20		1
				Run-off from interior areas	20		1
				Do Gooders	21		1
				Recreational fishing	23		1
				Lack of financial support for improvements	24		1
				Landholders who are yet to adopt best management practices. As in most cases, the minority are creating a negative stereotype despite the good work of the majority.	25		1

APPENDIX 12: FEEDBACK FROM LAND MANAGER SURVEY, IMPACT OF URBAN DEVELOPMENT ON WATER QUALITY

On 13/03/2018 12:44 PM, Participant Surname, Name supplied wrote:

Thanks for organising this survey.

Our question is, what are NQ Dry Tropics and JCU doing to assess and control the impact of townspeople on the Great Barrier Reef? Fertilisers are allowed to be applied without restriction to town blocks, which then run directly onto the Reef. The recent rain in Townsville washed the dust, filth and rubber from roads into the Reef. Sewerage pours in each day, and if organic farmers are unable to use treated sewerage water on their crops, why is it allowed to touch the Reef? Every time the Army bombs at High Range, the creeks and rivers run brown - yet they are allowed to continue unchecked. Developers can rip up and damage in Townsville and where does the Run-off go? Have a look at the construction of the new stadium and the fact it is beside the Ross River.

Your survey needs broadening.

We are tired of landholders being targeted when those who sit on the doorstep of the reef are left alone. When are they going to be put under the microscope instead of targeting us? Those who sit on the very edge of the Reef are impacting it most.

Thankyou,

Participant Name Surname Supplied

On 13/03/2018 6:55 PM, Researcher wrote:

Hi Participant Name,

Thank you for the feedback. I recognise and acknowledge your frustration. For this study we are focussed on cane growers and graziers and their views on issues surrounding water quality (and trying to keep our very long survey as short as possible). Our goal is to find out your views so as to recognise your efforts (as landholders) towards improving water quality. We hope to be able to use the results to compare to other study's to highlight the importance of improving run-off to the reef from all users, but in particular to recognise the efforts that farmers go to, to manage run-off.

Thank you for taking the time to complete the survey, we appreciate your involvement.

Researcher name supplied

On 14/03/2018 9:33 AM, Participant wrote:

Hi Researcher,

Thanks for your reply. Perhaps in your position, you could start the movement to advertise that every time a toilet is flushed or a tap is turned in a city, it impacts the reef. Media would have us believe it is all the farmers fault and it's about time this opinion was changed by directly challenging it.

Thankyou,

Participant

On 18/03/2018 8:44 AM, Researcher wrote:

Hi,

I think they are realising that they shouldn't point the finger at one party, because they know that WQ effects and is effected by everyone. In the past farming processes have been identified as high risk for run-off from nitrogen, pesticides and sediment, hence they see actioning farmers as important to reducing run-off. There is now acknowledgement that focussing on a single segment/industry may not be the way to go. The government is perplexed as to why when there is best management practice (bmp), that it is not being adopted. We suspect that most farmers are using bmp and we know that nearly all (there's always exceptions) farmers care deeply for their land. Hence the reason for the survey… we are trying to find out what farmers are doing in terms of bmp, and what they are doing differently to standard practice (and if it's working) and where processes/information can be changed to 'hear the farmers voice'.

The first round of literature review has shown that communication (or lack of it) has played a major role in poor relationships between government and land holders (again not always, but in many cases). But the data also showed that more than 60% of farmers did not think that their farming practices effected the reef… so we need to hear more about what land managers are doing 3 years later to see if anything has changed.

And that's where you come in… thanks for taking the survey… we are certainly working towards a more balanced view

Researcher

On 19/03/2018 8:39 AM, Participant wrote:

Isn't it interesting (and scary) that it has taken this long for common sense to prevail? I think farmer bashing is a popular sport and politicians get most votes from towns, so despite the fact that we feed them, they would like to think we are the enemy and don't count. This is why bmp isn't adopted, because no one wants to be on the government radar and be

persecuted. Farmers are the original conservationists. We care for and nurture our land to the detriment of our own health and relationships and are sick of those with no common sense coming out of a yearlong degree to lecture us.

What should happen, is that each farmer's knowledge and expertise of managing and preserving their land should be celebrated and shared without feeling that big brother is waiting to swoop.

If a greater focus was placed on townspeople, developers, the army and mining impact on the reef, farmers would feel less persecuted and would share their already effective practices. Most don't need to change their practices, as they aren't the sole reason for reef impact, the above groups need to be targeted (which would cost votes, hence the reason they never are, sadly).

Thanks again,

Participant

APPENDIX 13: PROJECT OUTPUTS

Technical Reports Published

Eagle, L., Hay, R., Farr, M. (2016) Harnessing the science of social marketing and behaviour change for improved water quality in the GBR: Background review of literature. Report to the National Environmental Science Programme. Reef and Rainforest Research Centre Limited, Cairns (98 pp.).

Hay, R., and Eagle, L., (2016) Harnessing the science of social marketing and behaviour change for improved water quality in the Great Barrier Reef: A documentary analysis of Reef Trust Tender (Burdekin) and Reef Programme. Report to the National Environmental Science Programme. Reef and Rainforest Research Centre Limited, Cairns (95 pp.).

Farr, M., Eagle, L. Hay, R., and Churchill, M. (2017) *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 (100pp.).

Farr, M., Eagle, L. Hay, R., and Churchill, M. (2017) *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 (124pp.).

Farr, M., Eagle, L., and 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 (70pp.).

Farr, M., Eagle, L., Hay, R. (2017). Supplementary Literature Review: Key determinants of pro-environmental behaviour of land managers in the agricultural sector for NESP Project 2.1.3. Harnessing the Science of social marketing and behaviour change for improved water quality in the GBR. Report prepared for the Australian Government - National Environmental Science Project.

Hay, R., & Eagle, L., (2018) Harnessing the science of social marketing and behaviour change for improved water quality in the Great Barrier Reef: Land Managers decision making about water quality: views from extension officers of the Wet Tropics, Queensland, Australia. NESP Project 2.1.3 Interim report. Report to the National Environmental Science Programme. Reef and Rainforest Research Centre Limited, Cairns.

The following guide has been published for associated NESP TWQ Hub Project 3.1.3

Hay, R., Eagle, L., & Chan, J. (2018). Harnessing the science of social marketing in communication materials development and behaviour change for improved water quality in the GBR: Best Practice GUIDE for Development and Modification of Programme Communication Material. Retrieved from http://www.nesptropical.edu.au

Refereed Journal Articles

Rundle-Thiele, S.R., David, P., Willmott, T., Pang, B., Eagle, L., Hay, R. (2019). *Delivering behavioural change: A theoretical research agenda*, Journal of Marketing Management, 35 (1-2), 160-181.

Hay, R., Eagle, L., Saleem, M., (2019). Social marketing's role in improving water quality on the Great Barrier Reef. Asia Pacific Journal of Marketing and Logistics.

Eagle, L., Hay, R. & Low, D. (2018) Competing and Conflicting Messages via Online Media: Potential impacts of claims that the Great Barrier Reef is Dying *Ocean and Coastal Management*, 158, 154-163.

Webinars

Eagle, L., Farr, M., and Hay, R. (2016) NESP Project 2.1.3: Progress update for harnessing the science of social marketing and behaviour change for improved water quality in the GBR: an action research project. In: Office of the Great Barrier Reef Webinar Series, pp. 1-31. From: Office of the Great Barrier Reef Webinar Series, 10 April 2016, Brisbane, QLD, Australia.

Eagle, L. (2016). Summary of Literature Review undertaken for Harnessing the science of social marketing and behaviour change for improved water quality in the GBR: an action research project. In: Office of the Great Barrier Reef Webinar Series, pp. 1-31. From: Office of the Great Barrier Reef Webinar Series, October 25 2018, Brisbane, QLD, Australia.

Hay, R., Eagle, L. & Farr, M. (2016). NESP Project 2.1.3: Harnessing the science of social marketing and behaviour change for improved water quality in the GBR: Documentary Analysis. In: Office of the Great Barrier Reef Webinar Series, pp. 1-31. From: Office of the Great Barrier Reef Webinar Series, 2 November 2018, Brisbane, QLD, Australia.

Emtage, N. (2017) *NESP Identifying and profiling landholder groups for social marketing: a Wet Tropics Study.* In: Office of the Great Barrier Reef Webinar Series, pp. 1-31. From: Office of the Great Barrier Reef Webinar Series, 31 January 2017, Brisbane, QLD, Australia.

Keynote Presentations

Eagle, L. (2018). *Keynote Speaker, Environmental Behaviour Change: Benefits, barriers and the need for integrated strategies.* Presented to the Estuarine and Coastal Sciences Association Conference (ECSA57): Perth 3 – 6 September 2018

Hay, R. (2018). *Keynote Speaker: Marketing communication and effectiveness.* Presented to the Regional NRM Communication and Engagement Officers Network, Terrain NRM, Cairns, 2 August 2018

Paper Presented at Refereed International Practitioner Conference

Hay, R., Eagle, L. & Farr, M. (2017). *"Supporting and Extending the Role of Agricultural Extension Officers"*. Presented at the International Conference of the Australasia-Pacific Extension Network, September. Abstract appeared in conference proceedings.

Paper Presented at Refereed International Academic Conference

Hay, R., Eagle, L. & Low D.R. (2017). "Farmer segmentation and the transfer of knowledge in extension". In proceedings of the Australia New Zealand Marketing Academy Conference (ANZMAC), RMIT Melbourne, December.

Papers under Development and Review

Under development

Rundle-Thiele, S. Pang, B., David, P., Wilmott, T., Eagle, L. & Hay, R. *Synthesis of NMSC and CBSM benchmarks* – Target journal. *Journal of Social Marketing*

Eagle, L., Hay, R., Kubacki, K., & Rundle-Thiele, S. *Social marketing will be used to "overcome" opposition: Really?* Target journal: *Journal of MacroMarketing*

Eagle, L., Hay, R., Rundle-Thiele, S., & Roemer, C. Engaging with the Disengaged: A Collaborative Partnership Approach to Agricultural Land Practice. Target Journal: *Environmental Science & Policy*.

Eagle, L., & Hay, R. Supporting and Extending the Role of Agricultural Extension Officers. Target journal: Journal of Agricultural Education and Extension

Hay, R., & Eagle, L. Farmers typology and its importance for successful extension programs – North Queensland (Australia) study. Target journal: Land use policy

Eagle, L. & Hay, R. "Gloom and Doom versus Hope for Recovery: Changing Tone in Media Coverage of the Great Barrier Reef". Target Journal: *Communication Research*.

Presentations to Industry Bodies

Hay, R., Eagle, L. & Farr, M. (2016). Project Overview for Harnessing the science of social marketing and behaviour change for improved water quality in the GBR: an action research project. Presentation to Successful Projects Sharing Day: Working together to improve water quality group. Hosted Department of Environment and Heritage Protection, 15 April 2016.

Eagle, L., Hay, R. & Farr, M. (2016). Project Overview for Harnessing the science of social marketing and behaviour change for improved water quality in the GBR: an action research project. Presentation to NQ Dry Tropics Staff, 18 October, 2016.

Eagle, L., Hay, R. & Farr, M. (2016). Project Overview for Harnessing the science of social marketing and behaviour change for improved water quality in the GBR: an action research project. Presentation to Terrain Staff, 14 December 2016.

Eagle, L., Hay, R. & Farr, M. (2017). Wet Tropics Sugar Industry Partnership Management Committee Presentation re first round of data from NESP project, April 3, 2017.

Eagle, L., Hay, R. (2017) Social Dimensions Workshop coordinated by Department of Environment and Heritage Protection. Presentation to delegates, Brisbane, 31 January 2017.

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