

Revealing innovation discourses in the sugar cane sector

Using Q methodology to reveal dominant discourses around innovation and innovative incentive approaches in the sugar cane sector in the Wet Tropics Region of Queensland

Andrew Buckwell, Maria Ribbeck, Joshua Dyke and James C R Smart



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Supported by the Australian Government's
National Environmental Science Program

Project 3.1.6 Exploring trading in water quality credits as a cost-effective approach for managing water quality in the Great Barrier Reef

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National Library of Australia Cataloguing-in-Publication entry:
978-1-925514-66-7

This report should be cited as:

Buckwell, A, Ribbeck, M, Dyke, J. and Smart, J. C. R. (2020) *Revealing innovation discourses in the sugar cane sector: Using Q methodology to reveal dominant discourses around innovation and innovative incentive approaches in the sugar cane sector in the Wet Tropics Region of Queensland* Report to the National Environmental Science Program. Reef and Rainforest Research Centre Limited, Cairns (50pp.).

Published by the Reef and Rainforest Research Centre on behalf of the Australian Government's National Environmental Science Program (NESP) Tropical Water Quality (TWQ) Hub.

The Tropical Water Quality Hub is part of the Australian Government's National Environmental Science Program and is administered by the Reef and Rainforest Research Centre Limited (RRRC). The NESP TWQ Hub addresses water quality and coastal management in the World Heritage listed Great Barrier Reef, its catchments and other tropical waters, through the generation and transfer of world-class research and shared knowledge.

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ACRONYMS

ACCC	Australian Competition and Consumer Commission
DIN	Dissolved Inorganic Nitrogen
GBR	Great Barrier Reef
MDB	Murray Darling Basin
NESP	National Environmental Science Program
NRM	Natural Resource Management
TWQ	Tropical Water Quality

EXECUTIVE SUMMARY

Sugarcane farming has a long-established history in North Queensland and is a dominant land-use in lowland tropical areas, where catchments empty into the Great Barrier Reef (GBR) lagoon. The cane sector provides significant economic benefit to regional Queensland, is an important aspect of local cultural identity, and a major shaper of the physical landscape. Cane farmers face increasing scrutiny associated with the impacts of fertiliser run-off and the sector is subject to regulatory reform as a significant source of dissolved inorganic nitrogen (DIN), which is implicated as a threat to the condition of the GBR and the economic benefit and ecosystem services the GBR provides to Australians.

Use of market-based instruments to meet policy objectives has become a favoured approach to pollution abatement, particularly where the costs of reducing emissions is not uniform across liable entities. The attractiveness of market-based approaches rests on the assumptions behind conventional economic behaviour – permitted polluters will increase abatement until the point marginal abatement costs equals permit prices, or compensation scheme payments. Farmer engagement in such schemes is driven by both *external* factors, such as the voluntary or involuntary nature of the scheme, market signals, and biophysical constraints and by *internal* (to the individual) factors, such as personal attitudes, behavioural controls, and personal moral norms. Therefore, though adequate financial incentives are necessary, they are insufficient in driving take-up. Thus, understanding attitudes and perspectives in the cane sector towards innovation is vital to predicting the likelihood of uptake of incentive schemes, such as water quality trading markets.

We used Q methodology (hereafter Q) to identify these attitudes and perspectives. Q is both a *quantitative* and a *qualitative* method based on statistical analysis of survey respondents' subjectivity. Q facilitates the ordering of statements by respondents onto a grid, ranking them from most to least salient in response to a primer question. Respondents' individual sorts are subject to factor analysis and rotated to reveal a number of factor arrays. These correlations across statement salience rankings are then interpreted into common language descriptions, or 'discourses' around a subject domain. Q has only been used sporadically in the study of water quality trading, farming and land use, and in this study has revealed some useful insights into attitudes and perspectives that could affect acceptance of water quality trading systems amongst cane growers. Specifically, our research questions were: (i) what are the key discourses present amongst stakeholders associated with the sugar cane growing industry in GBR catchments; (ii) which discourses are most associated with positive attitudes towards innovation and a higher likelihood of participating in schemes, such as water quality trading; and (iii) which socio-demographic attributes have a greater propensity to align with the discourses most sympathetic to innovation.

Our data was collected in the Wet Tropics region, around the town of Tully. This region is characterised by modest-sized, family-owned farms. Surveying took place in a dynamic policy environment, which likely influenced survey responses. In the recent months the sector saw the introduction of pollution caps for DIN, the publication of the latest (and unfavourable) Reef Report Card, and the granting of AUD \$443 million to Reef restoration projects through the Great Barrier Reef Foundation. The convergence of environmental drivers, research backing, policy advances and legislative support generated a setting for innovation, particularly in

support of water quality improvement, potentially using market-based mechanisms, but also for scepticism and mistrust of government.

We sampled 24 respondents across the cane sector ¹. Our statement set for sorting comprised 36 statements based on qualitative data collected during an earlier discovery phase. Analysis of the results, based on assessments of shared positive, negative or neutral sorts, particularly at the extremes, distinguishing statements, and respondents' qualitative feedback from the survey process revealed four discourses: (i) *broad perspective pessimists*; (ii) *scientific rationalists*; (iii) *business-as-usual sceptics*; and (iv) *constructive optimists*.

(i) *Broad perspective pessimists'* concerns were dominated by big picture issues. Important was maintaining the role of agriculture as the mainstay of economy and soil management. This discourse believed agriculture could have a mutually positive impact on the environment and the economy. Discourse members had generally sceptical views of water quality monitoring and the veracity of the science behind it. Thus, trust in the efficacy of water quality trading was very low. Reflecting this general scepticism, this cohort was also relatively pessimistic about the future of cane farming and was concerned that farmers were unable to securely exit the sector. In our sample, broad perspective pessimists were all men and were the second oldest cohort with the second highest years' experience. It comprised of four farmers and one retailer.

(ii) *Scientific rationalists* had a strong scientific focus and preference for issues associated with pro-environmental attitudes, including high salience with Reef protection and attribution of the risks to GBR water quality to agriculture. However, this discourse believed that responsibility for restoration was shared between farmers and the community and that agriculture, when well-managed, could deliver benefits to both the economy and the environment. Despite a rationalist perspective, this discourse did not find strong salience with the efficacy of a water quality trading system. Scientific rationalists were weighted towards women and were the youngest cohort with the fewest years of experience. This group was dominated by agricultural extension officers and scientists. There were no farmers in this cohort.

(iii) *Business-as-usual sceptics* also believed agriculture could have a positive impact on both the local economy and the environment. They showed more faith in Canegrowers' Best Management Practice process compared to the Reef Regulations to drive up standards and in the ability of technology to keep improving profits. Pro-environment sentiments were ranked unfavourably. For example, business-as-usual sceptics consider the risk to the Reef from poor water quality is thought to be very significantly over-stated and that environmental concerns are inappropriately dominating policy. The group had a high degree of confidence (well-placed or otherwise) in their current performance and do not feel that recently introduced regulations will be a burden. This discourse is also sceptical of the efficacy of water quality trading markets. Despite the general scepticism of the science, this group still felt farmers would take action if they could see the evidence of nitrogen applications on DIN in rivers. An explanation for this might be a general attachment to 'common sense' a belief that action to reduce DIN emissions

¹ The data collection for this study overlapped with the 2020 Covid-19 pandemic. The pandemic had impacts on the scope and size of our study, as physical movement to undertake data collection became completely restricted for an indefinite time around mid-March 2020. The pandemic truncated sampling to only 24 stakeholders.

would be forthcoming once the science made the need for this sufficiently clear. Although the evidentiary threshold for this behaviour change remains unknown, it does demonstrate such a threshold may exist. Business-as-usual sceptics were all males and were the oldest group with the longest experience in the sector. This cohort contained two farmers and three agricultural extension officers.

(iv) *Constructive optimists* saw agriculture as the mainstay of the regional economy and took a constructive view towards the role of agricultural extension programs and technology and the need for the sector to take action to improve water quality to meet GBR conservation objectives. This discourse is also relatively optimistic about change and believes the sector is not structurally boxed-in by existing infrastructure and supply chains and can adapt to changing market conditions. Constructive optimists also have the strongest salience of any group with the efficacy of water quality trading. Environmental concerns were ranked relatively highly and there is a broad acceptance of the mainstream science of reef degradation. There were insufficient numbers of constructive optimists in the survey sample to assess gender balance and occupation, however, the group was younger and had less years' experience than the mean.

None of the discourses we revealed demonstrated a strong preference for statements associated with water quality trading or compensation mechanisms as effective drivers of behavioural change. Business-as-usual sceptics were the least disposed, followed by broad perspective pessimists, constructive optimists, and scientific rationalists. However, it should also be noted that, with the exception of statement directly addressing water quality trading markets, these statements did not engender any particularly strong negative sentiment either.

A consistent theme through all four discourses is the need to clearly demonstrate the impact of farming on DIN levels in the region's rivers. This suggests that efforts to find creative and engaging ways to present scientific data that directly connect excess nitrogen applications with DIN levels in groundwater and rivers would assist in helping stakeholders consolidate knowledge around DIN impacts on the Reef. Furthermore, for a regulatory market to ever be trusted, data must demonstrate attribution of the impacts to regulated entities with greater precision that is currently available, which requires additional improvements in monitoring and reporting. This sentiment was particularly prevalent amongst business-as-usual sceptics and constructive optimists.

The significant cohort of scientific rationalists established in cane growing regions through the NRM offices, such as Terrain in the Wet Tropics Region. NRM organisations have a broad reach, are well-known and well-trusted in the community and have 'convening power'. This cohort could be useful advocates in driving awareness and uptake of water quality trading schemes, provided they can be convinced of the economic potential and practical feasibility of these approaches. Our findings suggest that further effort in this direction is probably required.

Two discourses, broad perspective pessimists and business-as-usual sceptics doubted the efficacy of water quality trading. Both these cohorts were dominated by farmers. In addition, qualitative feedback from respondents cited the current implementation difficulties, in terms of transparency, prices and equity, of the Murray Darling Basin (MDB) water markets as the driver of their scepticism of water quality trading. We judge it is unlikely that markets for water *quality* will be supported by the agricultural sector until such time as perceived implementation issues with water *quantity* trading in the MDB are accepted as resolved by agricultural peak bodies.

More positively, there was a very high level of consensus between the four discourses for statements associated with the longevity and security of any compensation contracts. However, sentiment was generally not strongly positive. This suggests that though the efficacy of water quality trading markets may be far from proven, their capacity to deliver long-term streams of (adequate) compensation payments to farmers will assist in take-up.

1.0 INTRODUCTION

Sugarcane (cane) growing has a long-established history since white settlement and is a dominant land-use in lowland tropical areas of north eastern Queensland, where catchments flow eastwards into the Great Barrier Reef Marine Park (GBRMP) (Griggs, 2011). There are approximately 4,000 cane farming entities in Queensland, growing cane on approximately 380,000 hectares of land (see Figure 1). The cane sector, as a whole, provides significant economic benefit to regional Queensland and is an important aspect of local cultural identity and a major shaper of the physical landscape (Griggs, 2011; Queensland Farmers' Federation, 2020). However, cane farmers are facing increasing scrutiny associated with the impacts of fertiliser run-off and the sector is subject to regulatory reform as a significant source of dissolved inorganic nitrogen (DIN). DIN is a pollutant of concern and emanates from leakage of excess fertiliser applications into the waterways and subsequently into the Great Barrier Reef (GBR) lagoon, where it is linked to eutrophication and Crown of Thorns starfish outbreaks (Bell, 1992; Commonwealth of Australia and Queensland Government, 2016; Mallawaarachchi, Blamey, Morrison, Johnson, & Bennett, 2001; Miller et al., 2015).

The GBR is also crucial regional driver of employment, mainly in the recreation and tourism sectors, and its presence supports 58,000 jobs and contributes over \$5.4 billion to Australia's annual GDP (Deloitte Access Economics, 2017). In addition, the GBR provides significant ecosystem services, including wild fisheries, coastal protection from storm surge, and carbon sequestration in its mangroves and sea grass beds (Deloitte Access Economics, 2017; Waycott, Longstaff, & Mellors, 2005). Despite its significant value, its relatively robust conservation framework and significant public and private expenditure on protection and remediation, the GBR's coral cover is declining rapidly as an outcome of well-understood anthropogenic stressors, such as DIN emissions and its direct influences on COTS and eutrophication, exacerbating the adverse impacts of climate change. Therefore, key trade-offs exist between increasing costs in the cane sector by improving agricultural practice or land use change to reduce DIN and protecting the GBR by meeting the water quality targets set out in the Reef 2050 Water Quality Improvement Plan 2017-2022 (Commonwealth of Australia and Queensland Government, 2018).

The region and the cane sector are subject to a complex and elaborate policy framework, involving three tiers of government, private sector foundations, industry-funded science and advocacy bodies, and not-for-profits involved in land care, each with specific and often non-overlapping agendas (Brodie & Pearson, 2016; Waterhouse et al., 2017). Therefore, cane farmers are at the centre of myriad competing messaging and regulatory instruments, making their planning and decision-making subject to profit uncertainty and regulatory and reputational risk.

Use of market-based instruments to meet policy objectives has become a favoured approach for pollution abatement, particularly where the costs of reducing emissions are not uniform across liable entities. The attractiveness of market-based approaches is based on the assumptions behind expected utility theory and conventional economic behaviour – permitted polluters will increase abatement until the point marginal abatement costs equals permit prices, or compensation scheme payments (Simmons, Wilson, & Dean, 2020). The approach is consistent with the 'New Regulatory State' – a transformation in the discourse of the social contract, where the state seeks policy interventions that privatise (or 'marketise') provision of

public goods, such as a healthy GBR, but simultaneously increase the reach and scope of regulatory agencies (Godden, Rochford, Peel, & Caripis, 2013). This (re)positions the legitimate role of the public sphere ('government') vis-à-vis the private (the cane farmers in the market), where new governance arrangements redistribute social and economic risk to individual farmers to reflect informational efficiency and the discourse of 'small government'. Government manage risks by supervising liable private entities to manage their own risk. Regulated entities must manage their own responses within the constraints, for example, of limits on pollutant emissions. Such regulated entities best understand their marginal abatement costs of reducing emissions, either through practice change or land-use change, and whether they should trade rights to emit by evaluating whether marginal abatement costs are higher or lower than the floating prices of emissions permits. All government needs to do is determine the total quantity of DIN emissions allowable across all liable entities.

Farmer engagement and environmental behaviours and responses in the agricultural sector are driven by both *external* factors, such as market signals, income, and biophysical constraints and by *internal* (to the individual) factors (Simmons et al., 2020). External factors, such as agri-environmental schemes, which offer payment for behaviour change (improved environmental outcomes, for example), are based on the assumption that farmers will change land-use, or farming practice, when the compensation payment exceeds the expected reduction in profit from that paddock. However, in practice, though important, adequate financial incentives are necessary, but frequently insufficient in driving take-up – internal drivers also play a role (Rolfe & Harvey, 2017; Rolfe et al., 2018). Internal drivers, based in social sciences, remain relatively under-studied. The limited literature concludes that personal attitudes, behavioural controls (*what others like me are doing*), and personal moral norms are predictors of (pro-environmental) behavioural intention (Fielding, McDonald, & Louis, 2008; Klöckner, 2013). Problem awareness is also an important, but indirect, determinant of pro-environmental intention (Bamberg & Möser, 2007). Sustainable change to improved practices are reliant on changes in values and social norms (Grube, Mayton II, & Ball-Rokeach, 1994). Social norms and social verification are known to be drivers of farmer behaviour, particularly in tight-knit communities, such as cane farmers, where there is also an influential peak body. Common barriers to participation in practices that support broader public good outcomes can be: "the potential for lost productivity, different interpretations of what constitutes conservation, and limits to future development and land use options" (Moon & Cocklin, 2011, p. 331). Thus, understanding attitudes and sentiment in the cane sector is vital for predicting the likelihood that the water quality targets for the Reef can be met.

We used Q methodology (hereafter Q) to identify the range of perspectives on attitudes towards engagement in market-based mechanisms for pollution reduction in the cane sector. Q is considered both a *quantitative* and a *qualitative*, or a *quali-quantillogical*, method (Stenner & Stainton Rogers, 2004), based on statistical analysis of a person's subjectivity (Stephenson, 1953). It sits at the intersection of empirical-analytic methods of knowledge generation, with its emphasis on implied objectivity, replicability, and deduction, and discursive-contextual methods of knowledge, which emphasise personal realities, and a mutual understanding of shared experiences of the world (Gregory, 1978; Robbins & Krueger, 2000). Specifically, our research questions were: (i) what are the key discourses present amongst stakeholders associated with the sugar cane growing industry in GBR catchments; (ii) which discourses are most associated with positive attitudes towards innovation and a higher likelihood of participating in schemes, such as water quality trading; and (iii) which socio-demographic

attributes have a greater propensity to align with the discourses most sympathetic to innovation.

Q has been used sporadically in the study of discourses toward water quality trading, farming and land use. For example, Kerr and Bjornlund (2018) identify four farming discourses in relation to pollution mitigation in Canada: (i) *Incentive orienteers*; (ii) *Rural advocates*; (iii) *Honest brokers*; and (iv) *Progressive producers*. Incentive orienteers are the innovators; they see regulations as blunt instruments and market-based instruments as the best way of enabling improved water quality – the government should just get on with implementation. Rural advocates were keen to defend the rural way of life and tended towards rejecting taxes and transfers as they undermine a ‘moral code’ of (self-determined) stewardship of landscape assets. Honest brokers (generally not farmers or producers) tended to fit the administrative rationalism described by Dryzek (1997). Finally, progressive producers also could be identified as predisposed to innovation, however they framed their discourse from generally a position of market power and influence –they were already producers working to high standards, but in capital- and animal-intensive operations. They, too, were sceptical of subsidies. Buckley (2012) used Q to investigate attitudes towards abatement of nitrogen pollution from agriculture in Europe after four years of operation of a new suite of mechanisms. Buckley identified, again, four discourses in relation to water quality regulation: (i) *Constrained productionists* who are private property focused and sceptical of measures to improve water quality; (ii) *Concerned practitioners* who share these concerns but are generally more positive; (iii) *Benefit acceptors* who were environmentally focussed and positive towards the purpose and the implementation of the regulations; and (iv) *Regulation unaffected* who are unaffected by policy and remain indifferent.

Outside Q method, Simmons et al. (2020), using social science R-based survey methods, determined five typologies of (Australian) land-owners in relation to tree clearing: (i) *refusers* (pro-clearing anti-regulation, less trust in neighbours); (ii) *reluctant acceptors* (pro-clearing, anti-regulating, but trust their neighbours), (iii) *neutrals*; (iv) *acceptors*; and (v) *supporters*. Given the relative complexity of the north Queensland regulatory environment and myriad extension programmes, we expect our Q to reveal broadly corresponding discourses in terms of a gradient of sentiment towards acceptance of regulatory compliance and openness to innovation, but also seek to reveal attitudes towards trust in the connection between water quality and Reef health (as a direct challenge to the cane sector) and therefore the requirement for actions to improve water quality and faith in whether novel, market-based instruments have a practical and legitimate role to play in reducing the costs of compliance.

Our study builds on this corpus of knowledge around engagement of agriculture in incentive-based schemes more generally and amongst sugar cane growers in GBR catchments specifically. Understanding the range of perspectives in relation to innovation, technology and incentive-based mechanisms; towards the potential for practice and/or land use change to deliver nitrogen credits; around the general level of optimism or pessimism about the sector; and around attitudes towards regulation and private property can provide valuable insight into the potential for acceptance of water quality trading systems amongst cane growers.

Section 2 provides the geographic and political context to the study. Section 3 provides a short background to Q and then steps through the phases, describing the research discovery and design. Section 4 reports the results of the statistical analysis of data and then justifies our

thought process behind the formulation of the descriptions of our final discourses. Section 5 addresses our research questions and contains a discussion the implications of our findings and broadly compares our findings to Kerr and Bjornlund (2018) and Buckley (2012). We also look at some of the limitations of our study. Section 6 highlights key recommendations for action to advance water quality trading markets in GBR catchments.

2.0 CONTEXT OF STUDY

Our study data were collected in the Wet Tropics Natural Resource Management (NRM) region of north Queensland around the town of Tully. The Wet Tropics growing region is characterised by rain reliant growers on the coastal plains. Cane farms in the Tully catchment tend to be small, family owned operations, between 40-250 hectares (Canegrowers, 2017). Frequently, farmers manage land on behalf of older, retired or semi-retired growers. Catchments are predominantly fast flowing, relatively short, permanent rivers flowing into the GBR lagoon where the outer reef is approximately 30 km offshore. Emissions of pollutants of concern is dominated by DIN exports.

Our data collection was undertaken at an important juncture in GBRMP and DIN and sediment emissions policy, which was likely to have a short-term impact on choices in our study. Firstly, in September 2019, the Queensland Government legislated *The Environmental Protection (Great Barrier Reef Protection Measures) and Other Legislation Amendment Bill 2019*, which, for the first time, imposed caps on emissions of DIN, sediment, and pesticides at GBR catchment river mouths and set minimum practice standards for the agricultural sector, including cane, bananas, and cattle grazing. The legislation was not politically bipartisan and was controversial amongst community leaders and cane growers, with numerous media reporting on a sense of “demonisation” of the agricultural sector (ABC News, 2019b). The cane peak body, Canegrowers, strongly objected to the legislation, lobbied against it and supported local chapters to hear from organisations that questioned the links between agricultural emissions and poor GBR health (ABC News, 2019b; Canegrowers, 2019a; The Guardian, 2019). This reflected an overall low level of trust between the Queensland Government and the agricultural sector (Dale, 2018). Secondly, in the weeks prior to this study, the most recent (five-yearly) *Outlook Report for the Great Barrier Reef 2019* was published by the Great Barrier Reef Marine Park Authority (GBRMPA, 2019). The report’s overall conclusion stated the GBR’s outlook should be downgraded from ‘poor’ to ‘very poor’; that “[w]ater quality targets are not being met, which is compounding the effects of climate change and slowing recovery of inshore ecosystems” (2019, p. 263); and that “[p]oor agricultural land management practices in the Catchment remain the greatest contributor to poor water quality” (2019, p. 263). Thirdly, in the 12 months prior to the study, the Commonwealth Government had made a significant investment in the GBR, by granting the private (and hitherto, little-known) Great Barrier Reef Foundation a donation of almost AUD \$450 million towards projects that support Reef protection and restoration (ABC News, 2019a). Simultaneously, the prospect of the new legislation limiting pollution exports promulgated significant organisational innovation in how the targets might be achieved.

The convergence of environmental drivers, research backing, policy advances and legislative support has generated a setting for innovation, particularly in support of water quality improvement and using market-based mechanisms (Buckwell, 2015; DEHP, 2014; Smart et al., 2016).

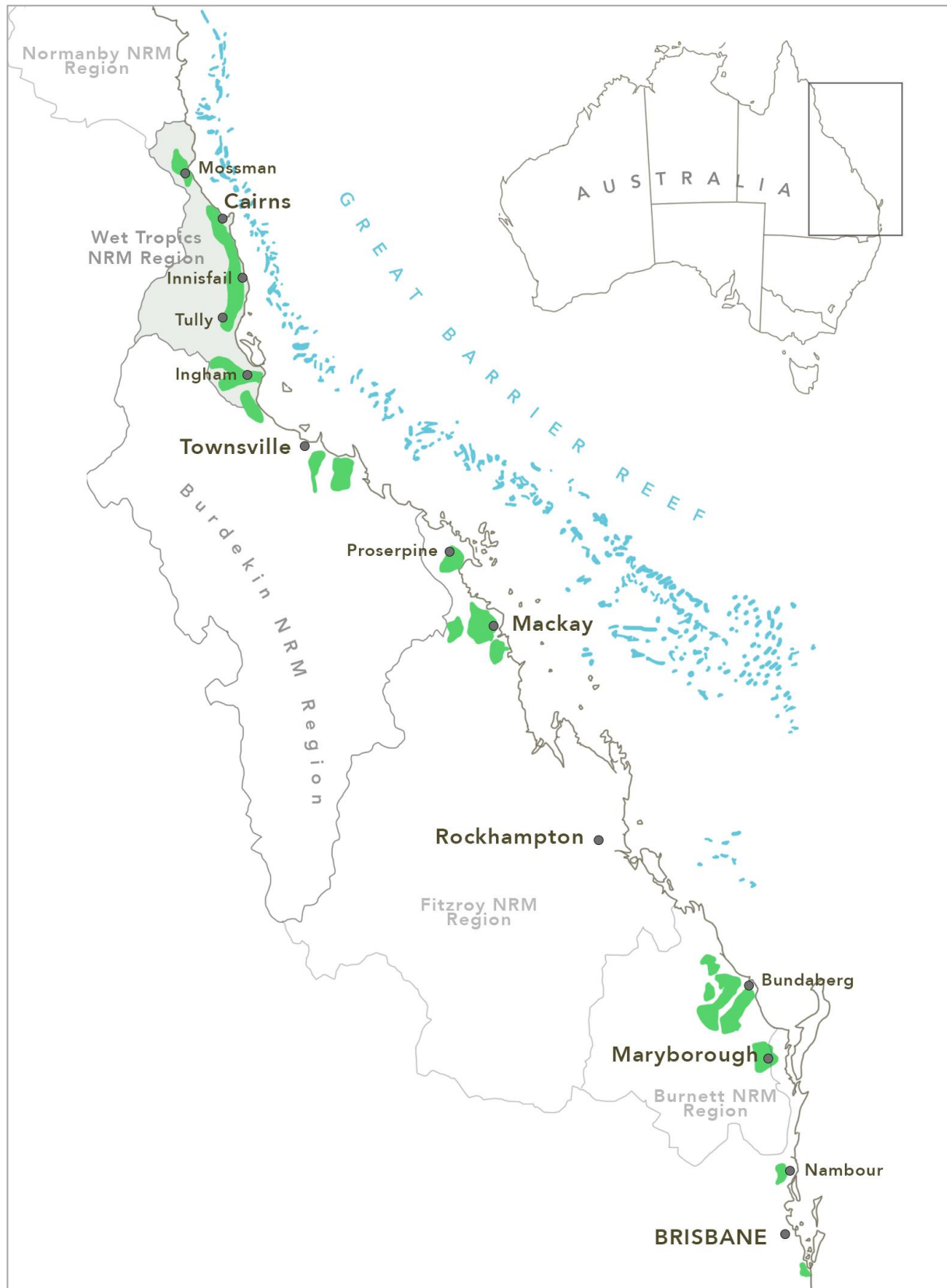


Figure 1: Map of the sugar cane growing areas (dark green areas) of Queensland.

Coronavirus impacts

The data collection for this study overlapped with the 2020 Covid-19 pandemic. The pandemic had impacts on the scope and size of our study, as physical movement to undertake data collection became completely restricted for an indefinite time around mid-March 2020. The original intention was to also sample key stakeholders in the Lower Burdekin region – specifically irrigating cane growers, in contrast to the rain-supplied growers in the Wet Tropics, however, this could not be done. The pandemic truncated our data collection, restricting sampling to only 24 stakeholders. Typically, a Q study should sample *at least* the same number of respondents as there are cards in the study (in our case 36) (Donner, 2001; Thompson, Frankiewicz, & Ward, 1983).

3.0 METHODOLOGY

3.1 Introduction to Q-method

Q demands abductive reasoning, whereby researchers seek the most likely conclusions from an incomplete set of observations (Langston et al., 2019, p. 5). Unlike R-based methods, such as Likert weighting scales, Q looks for correlations amongst subjects' views, rather than between object variables. These correlations reflect mindsets that are analogous to the structure of a discourse. Discourses are considered both external to individuals (they act *on* people) but are also emergent of collective heuristics of groups of people (people and power structures actively shape them) (Dryzek, 1994, 1997). An important assumption behind Q is that there are always a limited number of perspectives that exist in a group of people on a given topic (Barry & Proops, 1999); that is, people are consistent and coherent in their viewpoints and it is likely that people belonging to a particular mindset think about distinct issues in a consistent way. However, Q is not considered generalisable – it deploys strategic sampling of respondents, rather than large, randomised samples (applicable to R methods). Q is so-called as it is an inversion of R methodology. Unlike R methods, whereby the participants represent the sample and the attributes of the survey questions are the variables, in Q, the statements form the sample and the P-set (the people) is the variable. Therefore, randomly selecting participants would be the equivalent of randomly selecting variables in a traditional survey (Stevenson, 2015; Watts & Stenner, 2012). For this reason, strategic sampling is acceptable.

Operationally, Q facilitates the ordering of subjective viewpoints into clusters, elicited by asking respondents to sort statements (that are displayed on cards) onto a grid, ranking them from most to least negative, or salient. Commonly, respondents are required to sort the statements in a quasi-normal distribution, so there are fewer statements at the extremes, resulting in the respondent having to apply a higher cognitive load whilst sorting. Therefore, whilst a respondent may resonate positively with all statements, they are nevertheless compelled to consider them in relation to one another; or as Loring & Hinzman (2018) reflected from their fieldwork, a respondent stated: “they’re *all* really important, but...” (2018, p. 370). The act of sorting statements assumes a necessary level of comprehension in the respondent as to the wider purpose behind task (research), a reasonable level of trust between the survey team and respondent communities, a degree of literacy, and researchers with the requisite inter-personal skills to capture the qualitative aspects of the data collection.

When analysing the card sorts produced by individual respondents, what is important is the relationship between the placement of the statement cards as a whole, particularly those at the extremes. Where there is sufficient correlation between respondents' sorts, this is representative of a factor, which is used to generate an ‘ideal sort’ of the statements for that factor. An ideal sort is representative of a hypothetical respondent whose views would 100% overlap with the factor in the statement sorting. Typically, a factor should be representative of at least 4 to 5 respondents, but repeated sampling should continue until all new sorts begin to fall into stabilised factors. These ideal sorts are then further subjectively translated into concisely-worded descriptions of the salient features by the analyst to provide rich, contextual insight into the dominant perspectives of a given inquiry. Consistent with the literature, our Q research method is broken in to five phases (Donner, 2001; Dziopa & Ahern, 2011; van Excel & de Graaf, 2005), with phase 5 presented as laid out in the Results section

3.2 Phase 1: Determine the nature of the inquiry and community of interest

The first phase of Q is to set the primer question (see below) that elicits responses in the problem domain and then to determine the scope of the respondents, who are collectively referred to as the P-set. Selecting a reasonably diverse set of respondents provides greater opportunity to uncover more diverse viewpoints (Nguyen, Boruff, & Tonts, 2018; Webler, Danielson, & Tuler, 2009). Our P-set (Table 1) was sourced from (i) cane farmers in the Wet Tropics; (ii) agricultural extension officers; (iii) natural resource management organisations; (iv) government officers and policymakers; and (v) community members and members of community organisations.

Our primer question was:

“Thinking about the issues facing the sugar cane sector in Far North Queensland today, rank the following from statements from those which are most representative of how you think to those which are least representative of how you think”.

Box 1: Positive or negative salience

A Q sample should generally be balanced between positive and negative salience. For example, to reveal perspectives on the impact of run-off on the GBR, the researcher could present the following statement:

Scientists in government and the media are rightly concerned about the risk to the Great Barrier Reef’s health from agricultural run-off.

What is the likelihood that half of the Q participants would assign this a positive salience? There is no way to know. Therefore, it is recommended that there should be a mix of positive and negatively worded statements. In this instance, the above statement can be reworded to say:

The risk to the Great Barrier Reef’s health from agricultural run-off is over-stated by scientists in government and in the media.

Having a mix of positively and negatively worded statements is considered best practice (Webler et al., 2009).

Table 1: Key stakeholder groups (P-set) surveyed.

Stakeholder group	Sample identifying as	Respondents identifying as ‡
Farmer	Non-irrigating cane farmers (Wet Topics)	9
Farming contractor	Farming contractors who manage other’s farms	1
Agricultural extension	Wet Tropics Major Integrated Projects Team, Canegrowers Association	5
Science/NRM	Sugar Research Authority, Terrain NRM	9
Others	Policy, mill, retail	1

‡ Note that the total here equals 25, whilst 24 respondents formed our P-set. One respondent identified as both a farmer and a farming contractor.

3.3 Phase 2: Issue discovery, defining the concourse, determining the Q-set

The scope of the issues that will eventually form the set of statements is referred to as the ‘concourse’, or “domain of subjectivity” (Robbins & Krueger, 2000, p. 638) – the sum of things people say and *think* about a particular issue. The term ‘concourse’ suggests a crowded public space where (perhaps) a range of voices are attempting to be heard in order to articulate semi-

structured concepts. This is an advised metaphor, as the goal of forming the concourse is to elicit as many viewpoints as possible, through a deliberative, mixed-method approaches (Kenter et al., 2016; Kenter, Hyde, Christie, & Fazey, 2011).

Our concourse was generated from the following series of activities. Draft statement cards were generated from existing literature reviews, stakeholder interests, and prior informal interviews in the cane sector. We then further filtered our concourse, taking account of three requirements. Firstly, taking advice from Donner (2001), we ensured that, from a content perspective, statements avoided near duplicates, extreme statements (either positive or negative, as it is likely *everyone* will prioritise this card in the same way), and exact opposites. (See also, Box 1.)

We were careful to ensure that statements were constructed such that no single statement directly linked agricultural practice, particularly the application of nitrogen-based fertiliser, with direct damage to coral reef health on the Great Barrier Reef. Any connection, which reflects mainstream science (Bell, 1992; Commonwealth of Australia and Queensland Government, 2016; Mallawaarachchi et al., 2001; Miller et al., 2015), was only made through a series of steps in the statements so that respondents could rank each step independent of each other step. A draft set of statements was piloted with five respondents prior to further work to refine to final statements, or 'Q-set', which is set out in Table 2.

Table 2: Final statement set and evidence for inclusion

<i>Ref</i>	<i>Statement</i>	<i>Justification for inclusion of statement</i>
1	Farmers should be free to manage their agricultural operations as they see fit; with much less interference from government.	(de Groot & Steg, 2010; Villacorta, Koestner, & Lokes, 2003)
2	The new Reef Regulations for the agricultural sector expose landholders to unnecessary financial risk in planning their operations.	(Villacorta et al., 2003)
3	The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	Key research statement
4	Cane growers are kept sufficiently up-to-date about the requirements of farming regulations.	Evidence from discussions with cane growers
5	The environment should be balanced with the needs of the agricultural sector. At the moment, it feels like environmental concerns are dominant.	(Mallawaarachchi et al., 2001; Mallawaarachchi & Quiggin, 2001)
6	The sugar cane sector needs a shake-up. It risks losing the trust of the community, if it doesn't change.	(Heath, 2018)
7	It is likely most cane growers in this area will abide by the new Reef Regulations.	(Simmons et al., 2020)
8	Poor water quality in our rivers flowing into the Great Barrier Reef Marine Park is damaging the Reef environment.	(Kroon et al., 2012; Webster, Bartley, Armour, Brodie, & Thorburn, 2012)
9	Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.	(Canegrowers, 2019a)

10	Agricultural land uses, when well-managed, can have a positive impact on both the environment and the local economy.	(Mallawaarachchi & Quiggin, 2001)
11	A mix of different land-uses, including agriculture, bush, and wetlands provides for the best outcomes for farmers and the community in the long-term.	(Mallawaarachchi et al., 2001; Mallawaarachchi & Quiggin, 2001)
12	Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	(Zhao & Li, 2015)
13	Australia's agricultural and grazing sectors have traditionally been good stewards of the land, nature and the environment.	(Heath, 2018)
14	The risk to the Great Barrier Reef's health from agricultural run-off is over-stated by scientists in government and in the media.	(Canegrowers, 2019b, 2019a)
15	Maintaining the agricultural productivity of sugar cane in the long term is the biggest challenge for the sector in Far North Queensland.	(M. J. Bell, Garside, Halpin, & Berthelsen, 2001)
16	Farmers have a responsibility to reduce the impact of farming on water quality and the environment.	(Heath, 2018)
17	If Queensland cane farmers have to reduce their fertiliser applications to meet the new Reef Regulations, they will lose out to international competitors, who can use as much fertiliser as they want.	(Banerjee, 2005; Zimmermann & Zeddies, 2002)
18	Landscape management (caring for country) in our region would benefit from a greater inclusion of Indigenous and Traditional Knowledge.	(Grice, Cassady, & Nicholas, 2012; McIntyre-Tamwoy, Fuary, & Buhrich, 2013)
19	Managing wetlands and landscapes for environmental outcomes can play an important role in providing employment for Indigenous People.	(Grice et al., 2012; Maclean, 2015)
20	Farmers should be compensated for the time spent and capital investments needed to improve practice change beyond Canegrowers' 'Six Easy Steps' standards.	Key research question
21	A fixed-term financial compensation contract, at the appropriate rate, would be enough to persuade cane farmers to change practice to go beyond the Reef Regulations for fertilizer management.	(Calcino, Schroeder, & Hurney, 2010)
22	A long-term contractual payment plan could offset both the costs and risks of permanently converting a cane paddock to wetlands.	Key research statement
23	Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and maintaining profitability.	Terrain NRM
24	Higher levels of agricultural productivity can be sustained through adopting new technologies.	Key research statement
25	Looking after the soil, by better managing rotations, increasing its organic content, and reducing damage to soils during harvest can improve farm profitability and improve river water quality at the same time.	(M. J. Bell et al., 2001; George, Harper, Hobbs, & Tibbett, 2012; Greiner & Gregg, 2011)
26	Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	(Kroon, Robinson, & Dale, 2009; Robinson et al., 2016)

27	Cane farming offers a rewarding future for the next generation of growers.	Evidence from discussions with cane growers
28	The financial responsibility for landscape management and habitat protection should be shared between the community and the landholder/farmer.	Key research statement
29	Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	(Sheng & Chancellor, 2019)
30	The whole region's economy, infrastructure, and supply chain is set up to grow sugar cane – it would be very hard to grow and sell other crops.	(Griggs, 2011)
31	Cane growers would convert some of their low yield land to wetlands if the payments offered for this made it more profitable than growing cane there.	(Griggs, 2011)
32	The agricultural and grazing sectors are a mainstay of the Far North Queensland regional economy. Without a strong agricultural sector, the region would suffer.	(Canegrowers, 2019a)
33	Farmers would be much more inclined to manage nitrogen applications if they could see direct evidence of an impact on water quality in the rivers.	(Canegrowers, 2019a;) Evidence from Terrain
34	The new Reef Regulations will add significantly to farming costs through, for example, additional record keeping, planning and soil testing.	Evidence from Terrain
35	Where farmers can sell water quality credits into an open market is a trustworthy and dependable way of improving regional water quality.	Key research question
36	The new Reef Regulations are a blunt instrument for achieving better water quality outcomes. Industry BMP provides a more flexible route to water quality improvements.	Evidence provided by Canegrowers

3.4 Phase 3: Data collection

Substantive data collection was carried out in January 2019 in the Tully area of North Queensland (see also, note above, concerning the Covid-19 pandemic). We used a large 'playing mat' for the sorting (Figure 2). Each of the respondents' sorts was placed on a quasi-normal distribution containing 36 placements from +5 to -5, including zero, in increasing order of salience. Data collection took place over a period of three days; implemented by a team of three. Recruitment of respondents was undertaken by the good offices of Terrain NRM, who also hosted many of the respondent sorts. The majority of sorts for farmers were completed at their farms; either in the farm shed or at their homes – a model of engagement that many farmers, unprompted, were appreciative of.

An important aspect of Q is the capacity for qualitative assessment through observation of respondents' sorting strategies and by asking of respondents to articulate their thought processes, or 'think out aloud'. This assists with the formulation of the rich text descriptions of each of the key factors. Many useful observations were made, either through watching the card sorting, or from key elements of dialogue captured during the process. Sorting strategies from the group were relatively consistent. Predominantly, respondents took one card a time and placed it approximately in either a positive, neutral or negative position. Once this process

was completed, the cards were finally placed in the columns, generally starting towards 'More how I think ...' and working backwards. The layout and design of our sorting board is shown in Figure 2. We used relatively large, bold research materials (the sorting board was 1100mm x 750mm) making the process more engaging and making card placement and refinement easier.

Figure 2: Sorting mat used for Q method

3.5 Phase 4: Statistical analysis

Statistical analysis was undertaken with the web application Ken-Q Analysis (Banasick, 2018). We calculated the correlations between the participants' Q sorts to create a 'correlation matrix', which is then subject to factor analysis. Considerations of statistical significance should not preclude qualitative judgements about appropriate factor solutions; that is, when using Q, it is feasible, based on expert judgement or from earlier consultative activities, to have *a priori* insight into the likely factors. The factor analysis can theoretically produce any number of statistically relevant outputs, however, through an iterative process, which included consistently asking the following questions: (i) is the candidate factor statistically relevant, with an Eigenvalue greater than 1; (ii) are there more than two participants who are highly correlated within one factor and no other; and (iii) do the participant clusters agree with qualitative data and observations from interviews and focus group discussions (Stevenson, 2015). High factor stability is considered to have been achieved when a dozen-or-so respondent sorts load into a factor. Moderate stability is when 6 to 8 load into a sort (Kerr & Swaffield, 2012). Confounding sorts (respondents who load into more than one factor) and null sorts (respondents who do not load into any factor) are discarded, however these sorts are included in the analysis of consensus statements and low-scoring statements (see below).

4.0 PHASE 5: RESULTS

4.1 Summary results

We collected 24 responses (see note above in relation to the Covid-19 Pandemic). Statistical analysis of these responses revealed four dominant factor loadings (demonstrated by the Eigenvalues in Figure 3), with one factor particularly strongly evident and three others somewhat less prominent, followed by a long tail, with less significant differences between them². These four dominant factors were extracted and rotated via Varimax Rotation. Together these factors explained 59% of the total variation in the sorts, which meets the threshold of 35%-40% suggested by Kline (1994) (see Table 3).

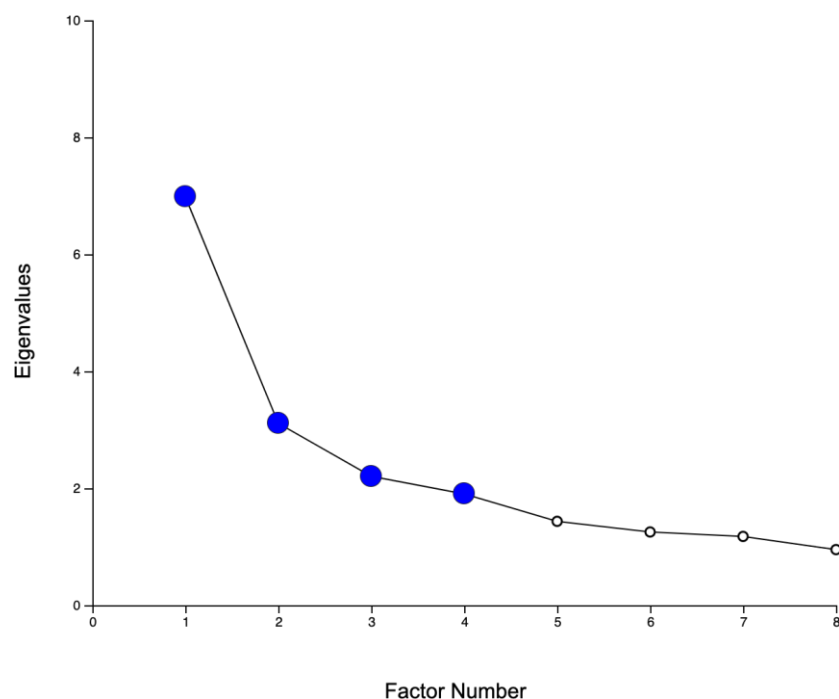


Figure 3: Scree plot of Eigenvalues of principal components from our factor extraction. Factors that were extracted for assessment are marked in bold.

Respondents were assigned into factors with p-value of < 0.05, using Ken-Q Analysis auto-flag function. Of the 24 respondents, 20 loaded into one of the four rotated factors. Four respondents did not load into any factor and were discarded (it is assumed that respondents who do not load into a factor are a combination of respondents with confounding views or respondents who did not comprehend the task). The ideal sorts for the four factors are shown in Figures 4 – 7 below. An ideal sort is the pattern expected if a respondent loads 100% into that factor. (In reality, the highest loading respondent into Factor 1 loaded at 0.7271, Factor 2

² Eigenvalues can be calculated by multiplying the variance times the number of participants and dividing this by 100. Eigenvalues are used in factor analysis to describe variance. Values less than 1 are discarded. However, the importance of keeping or discarding factors is more about the coherence of the factor rather than the reported eigenvalue (Herrington & Coogan, 2011).

at 0.6771, Factor 3 at 0.6658, and Factor 4 at 0.4925) The correlation between the each of the four rotated factors is shown in Table 3.

Table 3: Results of Q factor analysis show Eigenvalues and cumulative percent of explained variance, (both for reported unrotated factors), number of defining sorts in each extracted factor (number of respondents who fit the factor) and the correlations between factors

Factor	Unrotated		Varimax rotated				
	Eigenvalues	Cumulative % of explained variance	Number of defining sorts variables	Correlations between factor scores			
				Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	6.98	29	5	1	0.215	0.224	0.369
Factor 2	3.11	42	7		1	0.161	0.495
Factor 3	2.20	51	5			1	0.307
Factor 4	1.90	59	3				1

4.2 Factor analysis

Factor analysis for Q is the qualitative process of interpreting and describing the rotated factor arrays. This can be based on assessments of shared positive, negative or neutral sorts, particularly at the extremes. We also consider distinguishing statements for each factor – those statements that load into one of the factors in a position that is significantly different from other or all factors, either higher or lower. Consensus statements are statements that all factors rank within a single score of each other in their ideal sorts.

The results for each of the four extracted factors are reported in Table 4. This shows the ranking of each statement in each of the ideal sorts and the z-score variance, or the degree of agreement amongst the factors of that statement's placement.

Table 4: Summary results for our Q-method showing statement placements for ideal sorts for Factors 1, 2, 3 and 4 and the level of z-score variance (level agreement over placement of the statement).

REF	Statement	F1	F2	F3	F4	Z-Score variance
22	A long-term contract could offset both the costs and risks of permanently converting a cane paddock to wetlands.	-2	0	-1	-1	0.038
7	It is likely most cane growers in this area will abide by the new Reef Regulations.	0	1	2	1	0.049
26	Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	-3	-1	-1	-1	0.070
10	Agricultural land uses, when well-managed, can have a positive impact on the both the environment and the local economy.	3	3	5	2	0.104
33	Farmers would be much more inclined to manage nitrogen application, if they could see direct evidence of an impact on water quality in the rivers.	1	2	4	4	0.146
21	A fixed-term compensation contract would be enough to persuade cane farmers to change practice to go beyond the Reef Regulations for fertilizer management.	-1	0	-1	1	0.160
11	A mix of different land-uses, including agriculture, bush, and wetlands provides for the best outcomes for farmers and the community in the long-term.	-1	1	1	2	0.220
16	Farmers have a responsibility to reduce the impact of farming on water quality and the environment.	4	4	1	3	0.231
25	Looking after the soil, by better managing rotations, increasing its organic content, and reducing damage to soils during harvest can improve farm profitability and improve river water quality at the same time.	4	5	2	2	0.237
6	The sugar cane sector needs a shake-up. It risks losing the trust of the community, if it doesn't change.	-5	-2	-5	-4	0.266
15	Maintaining the agricultural productivity of sugar cane in the long term is the biggest challenge for the sector in Far North Queensland.	2	0	-1	0	0.273
23	Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and staying profitable.	1	2	2	4	0.286
20	Farmers should be compensated for their time spent and for capital investments needed to improve practice change beyond Canegrowers' 'Six Easy Steps' standards.	1	-1	-2	0	0.301
3	The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	2	-2	0	-1	0.323
24	Higher levels of agricultural productivity can be sustained through adopting new technologies.	0	0	3	3	0.368
31	Cane growers would convert some of their low yield land to wetlands, if it was more profitable than growing cane there.	2	0	-1	-2	0.379

36	The new Reef Regulations are a blunt instrument in achieving better water quality outcomes. Industry BMP provides a more flexible route to improvements.	1	1	3	-1	0.404
28	Landscape management and protection of habitat on private property is a shared financial responsibility of the community and the landholder/farmer.	-1	3	0	-1	0.451
19	Managing wetlands and landscapes for environmental outcomes can play an important role in providing employment for Indigenous People.	-3	1	1	0	0.501
4	Cane growers are sufficiently kept up-to-date about the requirements of farming regulations.	-2	0	2	-2	0.518
17	If Queensland cane farmers have to reduce their fertiliser applications to meet the new Reef Regulations, they will lose out to international competitors, who can use as much fertiliser as they want.	1	-4	-2	-3	0.521
13	Australia's agricultural and grazing sectors have traditionally been good stewards of the land, nature and the environment.	0	-3	0	1	0.558
32	The agricultural and grazing sectors are a mainstay of the Far North Queensland regional economy. Without a strong agricultural sector, the region would suffer.	5	1	0	5	0.592
35	A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	-4	-1	-3	1	0.623
34	The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.	-1	-2	-4	1	0.656
8	Poor water quality in our rivers flowing into the Great Barrier Reef Marine Park is damaging the reef environment.	-1	4	0	3	0.664
18	Landscape management (caring for country) in our region would benefit from a greater inclusion of Indigenous and Traditional Knowledge.	-3	2	-2	-2	0.705
29	Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	3	-2	-2	0	0.717
9	Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.	-2	2	-3	-3	0.785
2	The new Reef Regulations for the agricultural sector expose landholders to unnecessary financial risk in planning their operations.	3	-3	-3	0	0.806
1	Farmers should be free to manage their agricultural operations as they see fit; with much less much interference from government.	-2	-3	1	-4	0.812
30	The whole region's economy, infrastructure, and supply chain is set up to grow sugar cane – it would be very hard to grow and sell other produce.	2	-1	0	-5	0.957
12	Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	0	3	-4	0	1.046

27	Cane farming offers a rewarding future for the next generation of growers.	-4	-1	1	2	1.150
5	The environment needs to be balanced with the needs of the agricultural sector. At the moment, it feels like environmental concerns are dominant.	0	-4	3	-3	1.205
14	The risk to the Great Barrier Reef's health from agricultural run-off is over-stated by scientists in government and in the media.	0	-5	4	-2	1.386

Through the following sections the following syntax conventions apply: 'significantly higher/lower' means the statement is ranked different to *all* other factors with p-value of less than 0.05; and 'very significantly higher/lower' means the statement is ranked differently to *all* other factors with a p-value of less than 0.01. To assist the reader with the reasoning behind our descriptions of the factors, when we refer to the placement of a statement we refer to both a shorthand description of the statement to ease cognitive load and the statement number (S) to be cross-referenced with Table 4.

We determined four discourses: (i) *broad perspective pessimists*; (ii) *scientific rationalists*; (iii) *business-as-usual sceptics*; and (iv) *constructive optimists*. These discourses are described in detail below.

4.2.1 Discourse 1: Broad perspective pessimists

This first factor's most salient views (either negative, or positive) were dominated by 'big picture' statements. S32 (agriculture is mainstay of economy) ranked most strongly, followed by S25 (looking after the soil). S10 (agriculture can have a broad positive impact) was ranked at +3, S30 (region's economy set-up for only cane) was ranked significantly higher than other factors, at +2, and S6 (sector needs a shake-up) was ranked in the lowest position.

This factor contained respondents with some constructive, but generally sceptical views of the water quality monitoring and science. On the one hand, one respondent stated "if growers could see that nitrogen was coming directly off their paddocks, I believe they would change tomorrow", but another stated "how can you trust something you can't see" and another questioned the integrity of the monitoring process, referring to monitoring stations that have been moved, which would have affected the data. Confirming this scepticism, S26 (N-reduction technologies are not viable) was ranked lowest (-3) compared with all other factors, S9 (agriculture has impact on water quality in rivers) was ranked at -2 and S11 (mix of different land uses providing best outcomes) was ranked very significantly lower by other factors (but only at -1). Underlining this general scepticism, this factor was also relatively pessimistic about the future of cane farming, ranking S27 (cane farming offers a rewarding future) at -4 (very significantly lower than all other factors), S2 (reef regulations are a risk to planning) at +3 (very significantly higher than all other factors), and S29 (making a living is tough, but leaving harder) at +3 (very significantly higher than all other factors).

S35 (the efficacy of water quality trading systems) was ranked at -4, the lowest ranking across the four factors. One respondent cited recent and generally unfavourable media coverage of the functioning of the Murray-Darling water trading scheme and Australia's history of rejecting carbon trading schemes as a reason for their scepticism. Attitudes towards agricultural extension programmes were still positive (S23, +1), however this statement was ranked significantly lower than by all other factors. Supporting this, one respondent stated that they felt, historically that "compensation packages" [co-funded programmes] need to be "solutions-based" and had been "poorly targeted". Other statement placements of note were S19 (landscape management can provide employment for Indigenous People), ranked very significantly lower than it did in all other factors and S14 (risk to the reef is over-stated) – the most divisive statement (see Table 10) – was ranked neutrally.

For the reasons stated above, we determined to label this group '*broad perspective pessimists*'. Broad perspective pessimists were all men and were the second oldest cohort (mean: 42 years), with the second most years' experience (mean: 26 years). The cohort comprised of 4 growers and 1 'other' (no doubt covariant with gender balance), who identified as 'retail'. The ideal sort for broad perspective pessimists is represented in Figure 4 and a summary of distinguishing statements is reported in Table 5.

-5	-4	-3	-2	-1	0	1	2	3	4	5
6. The sugar cane sector needs a shake-up. It risks losing the trust of the community, if it doesn't change.	35. A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	26. Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	22. A long-term contract could offset both the costs and risks of permanently converting a cane paddock to wetlands.	* 34. The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.	7. It is likely most cane growers in this area will abide by the new Reef Regulations.	* 33. Farmers would be much more inclined to manage nitrogen application, if they could see direct evidence of an impact on water quality in the rivers.	15. Maintaining the agricultural productivity of sugar cane in the long term is the biggest challenge for the sector in Far North Queensland.	** 29. Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	25. Looking after the soil, by better managing rotations, increasing its organic content, and reducing damage to soils during harvest can improve farm profitability and improve river water quality at the same time.	32. The agricultural and grazing sectors are a mainstay of the Far North Queensland regional economy. Without a strong agricultural sector, the region would suffer.
	** 27. Cane farming offers a rewarding future for the next generation of growers.	** 19. Managing wetlands and landscapes for environmental outcomes can play an important role in providing employment for Indigenous People.	9. Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.	** 11. A mix of different land-uses, including agriculture, bush, and wetlands provides for the best outcomes for farmers and the community in the long-term.	** 5. The environment needs to be balanced with the needs of the agricultural sector. At the moment, it feels like environmental concerns are dominant.	20. Farmers should be compensated for their time spent and for capital investments needed to improve practice change beyond Canegrowers' 'Six Easy Steps' standards.	31. Cane growers would convert some of their low yield land to wetlands, if it was more profitable than growing cane there.	** 2. The new Reef Regulations for the agricultural sector expose landholders to unnecessary financial risk in planning their operations.	16. Farmers have a responsibility to reduce the impact of farming on water quality and the environment.	
		18. Landscape management (caring for country) in our region would benefit from a greater inclusion of Indigenous and Traditional Knowledge.	4. Cane growers are sufficiently kept up-to-date about the requirements of farming regulations.	21. A fixed-term compensation contract would be enough to persuade cane farmers to go beyond the Reef Regulations for fertilizer management.	13. Australia's agricultural and grazing sectors have traditionally been good stewards of the land, nature and the environment.	** 17. If Queensland cane farmers have to reduce their fertiliser applications to meet the new Reef Regulations, they will lose out to international competitors, who can use as much fertiliser as they want.	3. The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	10. Agricultural land uses, when well-managed, can have a positive impact on the both the environment and the local economy.		
			1. Farmers should be free to manage their agricultural operations as they see fit, with much less much interference from government.	8. Poor water quality in our rivers flowing into the Great Barrier Reef Marine Park is damaging the reef environment.	12. Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	36. The new Reef Regulations are a blunt instrument in achieving better water quality outcomes. Industry BMP provides a more flexible route to improvements.	30. The whole region's economy, infrastructure, and supply chain is set up to grow sugar cane & it would be very hard to grow and sell other produce.			
				28. Landscape management and protection of habitat on private property is a shared financial responsibility of the community and the landholder/farmer.	* 14. The risk to the Great Barrier Reef's health from agricultural run-off is over-stated by scientists in government and in the media.	* 23. Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and staying profitable.				
					24. Higher levels of agricultural productivity can be sustained through adopting new technologies.					

Figure 4: Ideal sort for *broad perspective pessimists*. Asterisks indicate significance. * indicates $p < 0.5$, ** indicates $p < 0.01$, ▲ indicates the z-score for this statement was higher than in all other factors, ▼ indicates the z-score for this statement was lower than all other factors. Shaded boxes indicate consensus statements.

Table 5: Distinguishing statements for *broad perspective pessimists*. Asterisks indicate significance. * indicates $p < 0.5$, ** indicates $p < 0.01$, ▲ indicates the z-score for this statement was higher than in all other factors, ▼ indicates the z-score for this statement was lower than all other factors.

REF	Statement	Factor score	Z-score	Differential
29	Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	3	1.33 **▲	+1.33
2	The new Reef Regulations for the agricultural sector expose landholders to unnecessary financial risk in planning their operations.	3	1.13 **▲	+1.44
3	The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	2	0.66 *▲	+0.79
30	The whole region's economy, infrastructure, and supply chain is set up to grow sugar cane - it would be very hard to grow and sell other produce.	2	0.64 *▲	+1.15
33	Farmers would be much more inclined to manage nitrogen application, if they could see direct evidence of an impact on water quality in the rivers.	1	0.5 *▼	-0.61
17	If Queensland cane farmers have to reduce their fertiliser applications to meet the new Reef Regulations, they will lose out to international competitors, who can use as much fertiliser as they want.	1	0.39 **▲	+1.15
23	Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and staying profitable.	1	0.35 *▼	-0.71
5	The environment needs to be balanced with the needs of the agricultural sector. At the moment, it feels like environmental concerns are dominant.	0	0.24 **	+0.50
14	The risk to the Great Barrier Reef's health from agricultural run-off is over-stated by scientists in government and in the media.	0	-0.15 *	+0.14
34	The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.	-1	-0.23 *	+0.37
11	A mix of different land-uses, including agriculture, bush, and wetlands provides for the best outcomes for farmers and the community in the long-term.	-1	-0.33 **▼	-0.78
19	Managing wetlands and landscapes for environmental outcomes can play an important role in providing employment for Indigenous People.	-3	-1.27 **▼	-1.15
27	Cane farming offers a rewarding future for the next generation of growers.	-4	-1.93 *▼	-1.69

4.2.2 Discourse 2: Scientific rationalists

Factor 2 had a strong scientific focus and preference for issues often associated with the environment movement in Australia. For example, this factor ranked S8 (poor water quality in rivers damages the reef) and S16 (farmers have a responsibility to reduce impact on water quality) at +4 and ranked S9 (agriculture has impact on water quality in rivers) very significantly higher than did all other factors, at +2. S28 (landscape management is a shared financial

responsibility) was also ranked very significantly higher than other factors at +3, suggesting whilst this factor views that the community should bear some of the costs of improving water quality, it is the responsibility of the farmer to engage with the processes and institutions that enable this to happen – and these farmers have not traditionally been good stewards of the land and environment (S13, ranked at -3).

The lowest ranking statement was S14 (risk to the reef is overstated), which factor 2 ranked significantly lower than all other factors. Furthermore, this factor believed the environment is not prioritised over the agricultural sector (S5); that sugar cane farmers can meet the Reef Regulations with limited risk from competition (S17); and that these regulations are both legitimate (S1) and reasonably well communicated (S3). One respondent stated, “the reef regs [regulations] are a pretty low bar and shouldn’t stop growers making money”. The low risk from implementation of the Reef Regulations was a sentiment that was widely anecdotally reflected by a broad group of growers, who communicated a relative confidence that their practices were already sufficiently sound to meet regulations. This factor gave a very significantly higher ranking to S6 (sector needs a shake-up) than did all other factors, though this was still ranked lowly at -2.

The highest ranked statement was S25 (looking after the soil), however this statement was ranked relatively highly in all factors. This sentiment was further underlined by respondent statements alluding to concepts of ‘holistic’ farm management and connecting stewardship of the environment with stewardship of farmland: “If you are negatively impacting the environment, you will be negatively affecting your farm” and that farmers should “work with the environment, not against it”. Factor 2 ranked the two statements (S18 and S19) associated with Indigenous Peoples’ involvement in landscape management higher than all other factors. S18 (landscape management would benefit from Indigenous knowledge) was ranked very significantly higher than all other factors. Combined, this was the only factor to rank the two statements positively.

Interestingly, despite the generally rationalist perspective, factor 2 did not find strong salience with S35 (the efficacy of a water quality trading system), nor S20 (compensation beyond Six Easy Steps) – two statements associated with the economic aspects of improving water quality. However, the more general statement, S28 (landscape management is a shared financial responsibility) was very significantly more highly ranked by this factor. This observation suggests that the attachment to scientific rationalism and a faith in the science of water quality’s impact on the GBR does not necessarily extend to an economic rationalism. For these reasons, we have labelled this factor ‘*scientific rationalists*’.

Scientific rationalists were weighted towards women and were the youngest (mean: 36 years old) with fewest years of experience (mean: 11 years). Unsurprisingly, professionally, this group was dominated by agricultural extension officers and science officers (which is likely covaried with the gender alignment). There were no farmers in this cohort. The ideal sort for scientific rationalists is represented in Figure 5 and a summary of distinguishing statements is reported in Table 6.

-5	-4	-3	-2	-1	0	1	2	3	4	5
*▲ 14. The risk to the Great Barrier Reef's health from agricultural run-off is over-stated by scientists in government and in the media.	17. If Queensland cane farmers have to reduce their fertiliser applications to meet the new Reef Regulations, they will lose out to international competitors, who can use as much fertiliser as they want.	2. The new Reef Regulations for the agricultural sector expose landholders to unnecessary financial risk in planning their operations.	29. Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	** 27. Cane farming offers a rewarding future for the next generation of growers.	31. Cane growers would convert some of their low yield land to wetlands, if it was more profitable than growing cane there.	* 32. The agricultural and grazing sectors are a mainstay of the Far North Queensland regional economy. Without a strong agricultural sector, the region would suffer.	33. Farmers would be much more inclined to manage nitrogen application, if they could see direct evidence of an impact on water quality in the rivers.	**► 12. Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	8. Poor water quality in our rivers flowing into the Great Barrier Reef Marine Park is damaging the reef environment.	25. Looking after the soil, by better managing rotations, increasing its organic content, and reducing damage to soils during harvest can improve farm profitability and improve river water quality at the same time.
	5. The environment needs to be balanced with the needs of the agricultural sector. At the moment, it feels like environmental concerns are dominant.	1. Farmers should be free to manage their agricultural operations as they see fit; with much less much interference from government.	**► 6. The sugar cane sector needs a shake-up. It risks losing the trust of the community, if it doesn't change.	20. Farmers should be compensated for their time spent and for capital investments needed to improve practice change beyond Canegrowers' 'Six Easy Steps' standards.	24. Higher levels of agricultural productivity can be sustained through adopting new technologies.	11. A mix of different land-uses, including agriculture, bush, and wetlands provides for the best outcomes for farmers and the community in the long-term.	**► 9. Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.	10. Agricultural land uses, when well-managed, can have a positive impact on the both the environment and the local economy.	16. Farmers have a responsibility to reduce the impact of farming on water quality and the environment.	
		**▲ 13. Australia's agricultural and grazing sectors have traditionally been good stewards of the land, nature and the environment.	*▲ 3. The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	30. The whole region's economy, infrastructure, and supply chain is set up to grow sugar cane & it would be very hard to grow and sell other produce.	21. A fixed-term compensation contract would be enough to persuade cane farmers to go beyond the Reef Regulations for fertilizer management.	36. The new Reef Regulations are a blunt instrument in achieving better water quality outcomes. Industry BMP provides a more flexible route to improvements.	23. Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and staying profitable.	**► 28. Landscape management and protection of habitat on private property is a shared financial responsibility of the community and the landholder/farmer.		
			* 34. The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.	* 35. A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	22. A long-term contract could offset both the costs and risks of permanently converting a cane paddock to wetlands.	7. It is likely most cane growers in this area will abide by the new Reef Regulations.	**► 18. Landscape management (caring for country) in our region would benefit from a greater inclusion of Indigenous and Traditional Knowledge.			
				26. Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	15. Maintaining the agricultural productivity of sugar cane in the long term is the biggest challenge for the sector in Far North Queensland.	19. Managing wetlands and landscapes for environmental outcomes can play an important role in providing employment for Indigenous People.				
					4. Cane growers are sufficiently kept up-to-date about the requirements of farming regulations.					

Figure 5: Ideal sort for *scientific rationalists*. Asterisks indicate significance. * indicates $p < 0.5$, ** indicates $p < 0.01$, ▲ indicates the z-score for this statement was higher than in all other factors, ▼ indicates the z-score for this statement was lower than all other factors. Shaded boxes indicate consensus statements.

Table 6: Distinguishing statements for *scientific rationalists*. Asterisks indicate significance. * indicates $p < 0.5$, ** indicates $p < 0.01$, ▲ indicates the z-score for this statement was higher than in all other factors, ▼ indicates the z-score for this statement was lower than all other factors.

REF	Statement	Factor	Z-score	Differential score
12	Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	3	1.37 **▲	+1.48
28	Landscape management and protection of habitat on private property is a shared financial responsibility of the community and the landholder/farmer.	3	1.24 **▲	+1.14
9	Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.	2	0.98 **▲	+1.47
18	Landscape management (caring for country) in our region would benefit from a greater inclusion of Indigenous and Traditional Knowledge.	2	0.84 **▲	+1.42
32	The agricultural and grazing sectors are a mainstay of the Far North Queensland regional economy. Without a strong agricultural sector, the region would suffer.	1	0.83 *	-0.41
27	Cane farming offers a rewarding future for the next generation of growers.	-1	-0.41 **	-0.17
35	A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	-1	-0.62 *	+0.03
6	The sugar cane sector needs a shake-up. It risks losing the trust of the community, if it doesn't change.	-2	-0.76 **▲	+0.87
3	The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	-2	-0.93 *▼	-0.80
34	The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.	-2	-1.03 *	-0.43
13	Australia's agricultural and grazing sectors have traditionally been good stewards of the land, nature and the environment.	-3	-1.46 **▼	-1.27
14	The risk to the Great Barrier Reef's health from agricultural run-off is over-stated by scientists in government and in the media.	-5	-1.61 *▼	-1.32

4.2.3 Discourse 3: Business-as-usual sceptics

This factor's most strongly ranked statement was S10 (agriculture can have a broad positive impact) and lowest ranked statement was S6 (sector needs a shake-up) – locating this factor firmly in a discourse of confidence in the cane sector's positive influence on the region's economy and landscape, and environment. This factor showed more faith in the BMP process than in the Reef Regulations (S36, +3, significant) and faith in the ability of technology to keep improving (S24, +3). Concerns, generally associated with the 'environment movement', were ranked very unfavourably. For example, the risk to the reef from poor water quality (S14) was thought to be very significantly over-stated (+4) and environment concerns were considered to be dominating policy (S5, +3; and significantly more so than in other factors). Climate change was not deemed to be a threat to the sector (significantly different), though from additional

feedback no consistent position on the science of climate change could be detected, although one respondent was confident conditions of climate change would benefit the sector.

Perhaps surprisingly for a discourse labelled 'sceptics' S34 (reef regulations will add to costs) was ranked lowly (-4). This suggested a high degree of confidence (well-placed or otherwise) amongst this cohort that they were already performing well and that further regulation will either not be a burden or not challenge the profitability of their operations. Supporting this supposition: S17 (threat of losing out to international competitors) was also not rated as a significant risk (-2); they felt they were sufficiently kept up-to-date with new reef regulations (S4, +2 and very significantly higher than other factors); and S20 (compensation as reward for improvement beyond Six Easy Steps) was ranked at -2. This last statement's low ranking is also related to a general sense of self sufficiency – one respondent was critical that some cane farmers were simply "lazy and just wanted a hand-out" (in the form of co-funding of practice improvement projects), and S1 (farmers should be free to manage their land) was ranked significantly more highly than by other factors, though only +1.

However, this salience with self-sufficiency is somewhat confounded by the slightly favourable attitude towards the role of agricultural extension programs (S23, +2). This group was also generally sceptical of the efficacy of water quality trading markets (S35, -3). Two of this cohort cited recent and generally unfavourable media coverage of the functioning of the Murray-Darling water trading scheme as reasons for the scepticism. Despite the general scepticism of the science, this group ranked S33 (farmers would act if they could see evidence of poor water quality) relatively highly (+4). A speculative explanation for this would be a general attachment to 'common sense' and a belief that action to reduce DIN emissions would be forthcoming once science was sufficiently clear. Though the evidentiary threshold for this change remains unknown, it does demonstrate that such a threshold may exist.

Overall, this group was confident in their practices and their ability to meet new regulations. However, they were sceptical of many of the scientific concepts associated with water quality, climate change and the requirement for further change. This group were *not* advocating for the status quo, nor were they actively oppositional to improvements in agricultural practices, further evidenced by one quote: "farmers who adopt [nitrogen application technologies] normally help their bottom line anyway". For these reasons, we have labelled them '*business-as-usual sceptics*'.

Business-as-usual sceptics were all males and were the oldest group (mean: 52 years old) with the longest experience in the sector (mean: 31 years). This cohort contained two farmers and three agricultural extension officers all from the farm productivity angle. The ideal sort for business-as-usual sceptics is represented in Figure 6 and a summary of distinguishing statements is reported in Table 7.

-5	-4	-3	-2	-1	0	1	2	3	4	5
6. The sugar cane sector needs a shake-up. It risks losing the trust of the community, if it doesn't change.	**◀ 12. Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	2. The new Reef Regulations for the agricultural sector expose landholders to unnecessary financial risk in planning their operations.	17. If Queensland cane farmers have to reduce their fertiliser applications to meet the new Reef Regulations, they will lose out to international competitors, who can use as much fertiliser as they want.	31. Cane growers would convert some of their low yield land to wetlands, if it was more profitable than growing cane there.	*◀ 32. The agricultural and grazing sectors are a mainstay of the Far North Queensland regional economy. Without a strong agricultural sector, the region would suffer.	**▶ 1. Farmers should be free to manage their agricultural operations as they see fit, with much less much interference from government.	23. Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and staying profitable.	**▶ 5. The environment needs to be balanced with the needs of the agricultural sector. At the moment, it feels like environmental concerns are dominant.	**▶ 14. The risk to the Great Barrier Reef's health from agricultural run-off is over-stated by scientists in government and in the media.	10. Agricultural land uses, when well-managed, can have a positive impact on the both the environment and the local economy.
	*◀ 34. The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.	35. A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	29. Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	21. A fixed-term compensation contract would be enough to persuade cane farmers to change practice to go beyond the Reef Regulations for fertilizer management.	13. Australia's agricultural and grazing sectors have traditionally been good stewards of the land, nature and the environment.	27. Cane farming offers a rewarding future for the next generation of growers.	**▶ 4. Cane growers are sufficiently kept up-to-date about the requirements of farming regulations.	*▶ 36. The new Reef Regulations are a blunt instrument in achieving better water quality outcomes. Industry BMP provides a more flexible route to improvements.	33. Farmers would be much more inclined to manage nitrogen application, if they could see direct evidence of an impact on water quality in the rivers.	
		9. Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.	18. Landscape management (caring for country) in our region would benefit from a greater inclusion of Indigenous and Traditional Knowledge.	22. A long-term contract could offset both the costs and risks of permanently converting a cane paddock to wetlands.	3. The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	19. Managing wetlands and landscapes for environmental outcomes can play an important role in providing employment for Indigenous People.	7. It is likely most cane growers in this area will abide by the new Reef Regulations.	24. Higher levels of agricultural productivity can be sustained through adopting new technologies.		
			20. Farmers should be compensated for their time spent and for capital investments needed to improve practice change beyond Canegrowers' 'Six Easy Steps' standards.	15. Maintaining the agricultural productivity of sugar cane in the long term is the biggest challenge for the sector in Far North Queensland.	28. Landscape management and protection of habitat on private property is a shared financial responsibility of the community and the landholder/farmer.	11. A mix of different land-uses, including agriculture, bush, and wetlands provides for the best outcomes for farmers and the community in the long-term.	25. Looking after the soil, by better managing rotations, increasing its organic content, and reducing damage to soils during harvest can improve farm profitability and improve river water quality at the same time.			
				26. Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	30. The whole region's economy, infrastructure, and supply chain is set up to grow sugar cane &" it would be very hard to grow and sell other produce.	**◀ 16. Farmers have a responsibility to reduce the impact of farming on water quality and the environment.				
					8. Poor water quality in our rivers flowing into the Great Barrier Reef Marine Park is damaging the reef environment.					

Figure 6: Ideal sort for *business-as-usual sceptics*. Asterisks indicate significance. * indicates $p < 0.5$, ** indicates $p < 0.01$, ▲ indicates the z-score for this statement was higher than in all other factors, ▼ indicates the z-score for this statement was lower than all other factors. Shaded boxes indicate consensus statements.

Table 7: Distinguishing statements for *business-as-usual sceptics*. Asterisks indicate significance. * indicates $p < 0.5$, ** indicates p of < 0.01 , ▲ indicates the z-score for this statement was higher than in all other factors, ▼ indicates the z-score for this statement was lower than all other factors.

REF	Statement	Factor score	Z-score	Differentia I
14	The risk to the Great Barrier Reef's health from agricultural run-off is over-stated by scientists in government and in the media.	4	1.54 **▲	1.61
5	The environment needs to be balanced with the needs of the agricultural sector. At the moment, it feels like environmental concerns are dominant.	3	1.27 **▲	1.28
36	The new Reef Regulations are a blunt instrument in achieving better water quality outcomes. Industry BMP provides a more flexible route to improvements.	3	1.22 *▲	0.52
4	Cane growers are sufficiently kept up-to-date about the requirements of farming regulations.	2	0.95 **▲	0.96
1	Farmers should be free to manage their agricultural operations as they see fit; with much less much interference from government.	1	0.77 **▲	1.40
16	Farmers have a responsibility to reduce the impact of farming on water quality and the environment.	1	0.34 **▼	-0.73
32	The agricultural and grazing sectors are a mainstay of the Far North Queensland regional economy. Without a strong agricultural sector, the region would suffer.	0	0.18 *▼	-0.84
12	Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	-4	-1.52 **▼	-1.44
34	The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.	-4	-1.65 *▼	-0.68

4.2.4 Discourse 4: Constructive optimists

High ranking concepts for Factor 4 were dominated by generally optimistic statements. As with Factor 1, this factor's highest ranked statement was S32 (agriculture is the mainstay of the regional economy) and S6 (sector needs a shake-up) was ranked at -4, underlining the central importance of agriculture, more generally, to this factor. This factor was significantly engaged with agricultural extension programs (S23, ranked at +4), the need for the sector to take action to improve water quality to protect the GBR (S8, ranked at +3), the role of technology in improving farm productivity (S24, ranked at +3), and that responsibility for this action predominantly rests with farmers (S16, ranked at +3).

Vis-à-vis the science of water quality and the impact on the GBR, one respondent stated they "had seen the evidence of nitrogen and phosphorous in the rivers, especially following heavy rain" and S14 (risk to the reef is overstated) was ranked at -2, its second lowest ranking, after factor 2.

This factor was also relatively optimistic about the change in the sector. S30 (the whole region's economy is set up for cane) was ranked lowest, very significantly lower than all other factors, suggesting that the sector is not structurally boxed-in by existing infrastructure and supply

chains. S36 (Reef Regulations are a blunt instrument) was ranked very significantly lower than other factors (-1), suggesting the Regulations were not completely unwelcome. This factor also had the strongest salience of any group with S35 (the efficacy of water quality trading); and very significantly so, though it was still ranked relatively neutrally (+1). Whilst this is not a ringing-endorsement, it underscores this factor's openness to change and new ideas.

There was a general sense of optimism that the region could adapt to growing alternative crops (S30, ranked very significantly lower at -5) and that the sector does not need a shake-up (S6, ranked at -4). Environmental concerns were ranked relatively high, with strong salience with a general acceptance of regulation of private property (S1, farmers should be free to manage their land, ranked at -4) and S5 (environment balanced with economy) leaning towards environmental concerns. S14 (risk to reef is over-stated) is ranked significantly lower, suggesting a broad acceptance of the mainstream science of Reef degradation. One respondent said, "growers have the best of intents. They have never set out to damage the environment". Another said, "If you do things badly, the next generation will follow, therefore what we do now is important for the future." In contrast and relatively anomalously to the generally optimistic and scientific acceptance sentiments, S9 (agriculture has impact on water quality in rivers) is ranked relatively lowly (-3). In addition, and in contrast to the factor 2, this factor was indifferent towards the role of Indigenous People in managing the wetlands in the landscape and the usefulness of traditional knowledge (S19 and S18, ranked 0 and -2 respectively). For these reasons we determined factor 4 to be '*constructive optimists*'.

There were insufficient members of constructive optimists to make any tentative assessment on gender balance and occupation, however, the group was younger than the mean (41 years) with less experience than the mean (18 years). The ideal sort for constructive optimists is represented in Figure 7 and a summary of the factor's distinguishing statements is reported in Table 8.

-5	-4	-3	-2	-1	0	1	2	3	4	5
*** 30. The whole region's economy, infrastructure, and supply chain is set up to grow sugar cane and it would be very hard to grow and sell other produce.	1. Farmers should be free to manage their agricultural operations as they see fit; with much less much interference from government.	5. The environment needs to be balanced with the needs of the agricultural sector. At the moment, it feels like environmental concerns are dominant.	31. Cane growers would convert some of their low yield land to wetlands, if it was more profitable than growing cane there.	3. The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	15. Maintaining the productivity of sugar cane in the long term is the biggest challenge for the sector in Far North Queensland.	*** 35. A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	10. Agricultural land uses, when well-managed, can have a positive impact on the both the environment and the local economy.	16. Farmers have a responsibility to reduce the impact of farming on water quality and the environment.	*** 23. Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and staying profitable.	32. The agricultural and grazing sectors are a mainstay of the Far North Queensland regional economy. Without a strong agricultural sector, the region would suffer.
	6. The sugar cane sector needs a shake-up. It risks losing the trust of the community, if it doesn't change.	9. Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.	18. Landscape management (caring for country) in our region would benefit from a greater inclusion of Indigenous and Traditional Knowledge.	28. Landscape management and protection of habitat on private property is a shared financial responsibility of the community and the landholder/farmer.	* 29. Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	13. Australia's agricultural and grazing sectors have traditionally been good stewards of the land, nature and the environment.	11. A mix of different land-uses, including agriculture, bush, and wetlands provides for the best outcomes for farmers and the community in the long-term.	24. Higher levels of agricultural productivity can be sustained through adopting new technologies.	33. Farmers would be much more inclined to manage nitrogen application, if they could see direct evidence of an impact on water quality in the rivers.	
		17. If Queensland cane farmers have to reduce their fertiliser applications to meet the new Reef Regulations, they will lose out to international competitors, who can use as much fertiliser as they want.	* 14. The risk to the Great Barrier Reef's health from agricultural run-off is over-stated by scientists in government and in the media.	*** 36. The new Reef Regulations are a blunt instrument in achieving better water quality outcomes. Industry BMP provides a more flexible route to improvements.	20. Farmers should be compensated for their time spent and for capital investments needed to improve practice change beyond Canegrowers' 'Six Easy Steps' standards.	*** 34. The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.	25. Looking after the soil, by better managing rotations, increasing its organic content, and reducing damage to soils during harvest can improve farm profitability and improve river water quality at the same time.	8. Poor water quality in our rivers flowing into the Great Barrier Reef Marine Park is damaging the reef environment.		
			4. Cane growers are sufficiently kept up-to-date about the requirements of farming regulations.	26. Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	19. Managing wetlands and landscapes for environmental outcomes can play an important role in providing employment for Indigenous People.	21. A fixed-term compensation contract would be enough to persuade cane farmers to change practice to go beyond the Reef Regulations for fertilizer management.	27. Cane farming offers a rewarding future for the next generation of growers.			
				22. A long-term contract could offset both the costs and risks of permanently converting a cane paddock to wetlands.	12. Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	7. It is likely most cane growers in this area will abide by the new Reef Regulations.				
					* 2. The new Reef Regulations for the agricultural sector expose landholders to unnecessary financial risk in planning their operations.					

Figure 7: Ideal sort for *constructive optimists*. Asterisks indicate significance. * indicates $p < 0.5$, ** indicates $p < 0.01$, ▲ indicates the z-score for this statement was higher than in all other factors, ▼ indicates the z-score for this statement was lower than all other factors. Shaded boxes indicate consensus statements.

Table 8: Distinguishing statements for *constructive optimists*. Asterisks indicate significance. * indicates $p < 0.5$, ** indicates $p < 0.01$, ▲ indicates the z-score for this statement was higher than in all other factors, ▼ indicates the z-score for this statement was lower than all other factors.

REF	Statement	Factor score	Z-score	Differential
23	Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and staying profitable.	4	1.85 *▲	+0.79
35	A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	1	0.62 **▲	+1.28
34	The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.	1	0.5 *▲	+1.10
29	Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	0	0.14 *	+0.14
2	The new Reef Regulations for the agricultural sector expose landholders to unnecessary financial risk in planning their operations.	0	-0.25 *	+0.06
36	The new Reef Regulations are a blunt instrument in achieving better water quality outcomes. Industry BMP provides a more flexible route to improvements.	-1	-0.56 **▼	-0.94
14	The risk to the Great Barrier Reef's health from agricultural run-off is over-stated by scientists in government and in the media.	-2	-0.94 *	-0.65
30	The whole region's economy, infrastructure, and supply chain is set up to grow sugar cane – it would be very hard to grow and sell other produce.	-5	-2.04 **▼	-1.53

4.3 Consensus and disagreement

Statistical analysis shows that the most similar factors in outlook were scientific rationalists and constructive optimists (0.495). The greatest difference in perspective was between scientific rationalists and business-as-usual sceptics (0.161) (see Table 3 in Section 3.1, above).

Table 9 and Table 10 report individual statements of consensus and disagreement between the four discourses. Consensus statements are relevant as they can represent potential starting points for community engagement and project development; in lieu of advocating for potentially more strongly-held (by some), but nevertheless more divisive, views. The six statements ³ demonstrating the greatest level of consensus are reported in Table 9. This table presents the z-score variance (level of agreement – lower values represent greater agreement) and average z-score across all four factors (representing the general level of salience across the four factors). S33 (attribution of nitrogen) has a high level of congruence (5th out of 36) *and* also a relatively high average z-score. This suggests, across all factors, that connecting on-

³ The listing of six statements, rather than five or seven, for example, is a judgement call.

farm decision-makers with data and building trust in these data is especially important. Also, of note, S22 (long-term contract could offset risks) and S21 (fixed-term compensation contract) suggests there is also agreement around the importance of stability in decision making and perhaps also around the role of compensation as an incentive mechanism. More constructively, there is a high level of agreement and generally positive sentiment towards farmers abiding by the new Reef Regulations. Of all the consensus statements, S10 (agriculture can have a broad positive impact) received the highest ranking, implying that when engaging with a broad set of stakeholders, an approach emphasising win-win type arrangements are a good place to start.

Table 9: Consensus statements

<i>REF</i>	<i>Statement</i>	<i>Average Z-score</i>	<i>Z score variance</i>
22	A long-term contract could offset both the costs and risks of permanently converting a cane paddock to wetlands.	-0.51	0.038
7	It is likely most cane growers in this area will abide by the new Reef Regulations.	0.54	0.049
26	Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	-0.81	0.070
10	Agricultural land uses, when well-managed, can have a positive impact on the both the environment and the local economy.	1.30	0.104
33	Farmers would be much more inclined to manage nitrogen application, if they could see direct evidence of an impact on water quality in the rivers.	1.11	0.146
21	A fixed-term compensation contract would be enough to persuade cane farmers to change practice to go beyond the Reef Regulations for fertilizer management.	-0.13	0.160

The six statements that provoked the greatest level of disagreement across the factors are reported in Table 10. Perhaps not unsurprisingly, given the current political context (see introduction) and a history of mistrust between farmers and Government (Dale, 2018), the statement with the highest incongruence was S14 (risk to the reef is overstated). This statement was ranked by scientific rationalists at -5 and by business-as-usual sceptics at +4. Related, S5 (environment needs to be balanced with the economy) and S12 (climate change will have an impact) were split along the same lines, only with less extreme differences between those two factors, implying environmental concerns are relatively divisive. S27 (cane farming offers a rewarding future) was ranked at -4 by broad-perspective pessimists, but otherwise was ranked broadly neutrally, or slightly positively.

Table 10: Statements of disagreements

<i>REF</i>	<i>Statement</i>	<i>Average Z-score</i>	<i>Z score variance</i>
14	The risk to the Great Barrier Reef's health from agricultural run-off is over-stated by scientists in government and in the media.	-0.29	1.386
5	The environment needs to be balanced with the needs of the agricultural sector. At the moment, it feels like environmental concerns are dominant.	-0.26	1.205
27	Cane farming offers a rewarding future for the next generation of growers.	-0.24	1.150
12	Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	-0.11	1.046
30	The whole region's economy, infrastructure, and supply chain is set up to grow sugar cane – it would be very hard to grow and sell other produce.	-0.51	0.957
1	Farmers should be free to manage their agricultural operations as they see fit; with much less much interference from government.	-0.79	0.818

5.0 DISCUSSION

Our study set out to understand the range of perspectives, or discourses, present in the cane sector in relation to: innovation, technology and incentive-based mechanisms; towards the potential for practice and/or land use change to deliver offsets; around the general level of optimism or pessimism about the cane sector; and around attitudes towards regulation and private property. This can provide valuable insight into the potential for acceptance of water quality trading systems amongst cane growers. We set out to understand (i) what are the key discourses present amongst stakeholders associated with the sugar cane growing industry in GBR catchments? (ii) which discourses are most associated with positive attitudes towards innovation and a higher likelihood of participating in schemes, such as water quality trading?; and (iii) which socio-demographic attributes have a greater propensity to align with the discourses most sympathetic to innovation?

5.1 Addressing the research questions

Our approach, using Q, identified four, clear discourses: (i) *broad perspective pessimists*; (ii) *scientific rationalists*; (iii) *business-as-usual sceptics*; and (iv) *constructive optimists*. None of the discourses demonstrated a strong preference towards a group of statements that spoke to the substantive research question most directly (S20, S21, S22, S28, S31 and S35, see Table 4 for details of the statements). Business-as-usual sceptics were the least disposed (-8 total across the six statements⁴), followed by broad perspective pessimists (-5), constructive optimists (-2) and, finally, scientific rationalists (-1). However, it should also be noted that, with the exception of S35 (efficacy of water quality trading markets), ranked at -4 by broad spectrum pessimists and -3 by business-as-usual sceptics, these six statements did not engender any particular strong negative sentiment either (the 'maximum' score possible for six statements would -22/+22).

We also collected limited socio-demographic data on age, years' experience in current position and occupation and, if a farmer, whether they had been involved in prior engagement schemes and the amount of land they had under sugar cultivation. It should be noted that the primary purpose of Q is not necessarily to find correlations between variables (as in an R-based survey), but to use 'strategic sampling' to determine the full range of perspectives. For this reason, it is only sometimes *possible* to find significant correlations between the factors and socio-demographic data and this is made more likely by collecting a large number of responses (Buckwell, Fleming, Muurmans, Smart, & Mackey, 2019). In this instance, given the restrictions on travel for data collection due to the Covid-19 pandemic (see Introduction), we did not collect sufficient data to run correlation tests, such as a regression analysis. Nevertheless, we report raw data here, in Tables 11 and 12, which provides some insight.

⁴ In all instances, a positive ranking demonstrates a preference for openness to water quality trading or compensation schemes.

Table 11: Socio-demographic make-up of each factor

<i>Factor</i>	<i>Gender</i>		<i>Mean age</i>	<i>Mean years' exp.</i>	<i>Mean area under can cultivation</i>	<i>Involvement in extension schemes</i>	
	<i>Female</i>	<i>Male</i>				<i>Government</i>	<i>Cane-growers</i>
Broad perspective pessimists	0	5	42	26	456 [‡]	2	2
Scientific rationalists	5	2	36	11	5 [‡]	1	2
Business-as-usual sceptics	0	5	52	31	258	1	
Constructive optimists	1	2	41	18	220 [‡]	3	1
<i>Total</i>	6	14	46.2	23.3	320	7	5

[‡] Result based on a single value.

[†] Results strongly influenced by one can farmer cultivating 1500 ha.

Table 12: Occupation by factor

<i>Factor</i>	<i>Occupation</i>					
	<i>Farmer</i>	<i>Contractor</i>	<i>Agricultural extension</i>	<i>Science</i>	<i>NRM</i>	<i>Other</i>
Broad perspective pessimists	4	-	-	-	-	1 (Retail)
Scientific rationalists	-	-	1	4	2	-
Business-as-usual sceptics	2	-	3	1	-	-
Constructive optimists	0.5 [‡]	0.5 [‡]	1	1	-	-
<i>Total</i>	6.5	0.5	5	6	2	1

[‡] Note that one respondent identified as both a farmer and a farming contractor

Business-as-usual sceptics were the oldest cohort and had the greatest number of years' experience, whilst scientific rationalists were the youngest and had the least number of years' experience. Farmers dominate broad perspective pessimists; scientific rationalists are mostly scientists and NRM employees; and business-as-usual sceptics are predominantly agricultural extension officers in support of the sugar sector. The picture for constructive optimists, unfortunately, is unclear. In respect of the substantive research question, understanding correlating socio-demographic attributes of this last factor, particularly in contrast to broad perspective pessimists, would be very useful. For example, by understanding what messaging might start to shift some broad perspective pessimists towards being constructive optimists, or what type(s) of engagement might prevent a potential drift towards general pessimism and scepticism as years of experience within the sector increase.

5.2 Comparison with previous studies

When we compare our Q results to those of Kerr and Bjornlund (2018) and Buckley (2012), we see a fair degree of alignment (see Table 13). There were three approximate analogues shared by all three sets of findings. Each shows a discourse that is a strong advocate for the role of agriculture as a key economic sector in rural areas. This discourse is generally sceptical of the science and the link between farm emissions and poor water quality; is sceptical of subsidy and transfers and is driven instead by a moral code to do what they think is right, rather than a demand for compensation; and is moderately propertarian (Widerquist & McCall, 2020). Each study also reveals a scientific rationalist or administrative rationalist discourse. This discourse is environmentally focussed and positive towards the justification and implementation of activities to improve water quality. In all studies, this discourse is commonly not comprised of farmers. However, in our study, scientific rationalists were more science-focused and lacked the clearer economic and administrative rationalism of benefit acceptors and honest brokers from the prior two studies. Finally, each study reveals a more progressive cohort, which does include *some* farmers, who are constructive, open to innovation, but would still benefit from a clearer demonstration of the science.

Though our study reveals and describes a cohort of constructive pessimists, no study reveals a *clear* cohort of *farmers* who reflect an unambiguous utility-maximising attitude, who would readily engage in water quality trading markets if they deemed it was profitable to do so. This reflects the findings of Rolfe et al. (2018) and Brown et al. (2020) who emphasise the importance of non-financial incentives (autonomy, longevity, social norms) in driving behaviour change. More data collection is required to determine the socio-demographic features of this cohort to design messaging and behaviour change programmes to suit this group.

Table 13: Best fit comparison of our factors and findings of previous Q method studies showing the authors' best alignment with previous Q studies on agricultural discourses on water quality trading schemes from Kerr and Bjornlund (2018) and Buckley (2012).

<i>Kerr and Bjornlund (2018)</i>	<i>Buckley (2012)</i>	<i>Our findings</i>	<i>Comparisons</i>
Incentive orienteers			No clear analogue in our results.
Rural advocates	Constrained productionists	Business-as-usual sceptics	Strong advocates for agriculture as a key sector in rural areas; sceptical of science; sceptical of subsidy and transfers; driven by moral code instead of needs for compensation; moderately propertarian.
Honest brokers	Benefit acceptors	Scientific rationalists	Predominantly non-farmers; scientific rationalists lack an administrative or economic rationalism inherent in honest brokers and benefit acceptors.
Progressive producers	Concerned practitioners	Constructive optimists	Disposed to innovation and optimism; keen to see clearer demonstration of science.
	Regulation unaffected		No clear analogue in our results.
		Broad perspective pessimists	No analogue in previous findings

5.3 Limitations of our study

We have already discussed the key limitation of our study – namely the impact of the Covid-19 Pandemic, which truncated our sampling.

More specifically, the pandemic restricted travel to alternative cane growing regions in Queensland. All cane farmers in the Tully region rely on rain for cropping. Farm operations, from the timing of planting, fertiliser application and harvesting are strongly influenced by weather. This is in contrast to the operations of cane farmers who have access to irrigation schemes, such as those in the Lower Burdekin, below the Burdekin Falls Dam, who can regulate watering and thereby have greater control over farm operations. However, they do face increase input costs due to the purchase of water and electricity for water pumping. It was our intention to travel to this region to sample Lower Burdekin cane farmers – as a representative sample of irrigating cane farmers – to test whether this greater control of farm operations and the increased input costs had a positive effect on their sentiment towards market-based instruments to improve water quality. This remains an important, outstanding adjunct to this study.

Though Q allows for strategic sampling, it remains difficult to reach a diverse range of farmers. Despite great efforts, the farmers we sampled were, at least to some extent, engaged in practice improvement by agricultural extension officers from Canegrowers, the local sugar mill,

or Terrain NRM's office in Tully. Our sampling therefore lacked perspectives from farmers who are not touched by behaviour change programs or messaging in support of improving water quality. It is unknown whether sampling such farmers would challenge, or extend, the factors uncovered in our study.

Finally, though sampling banana farmers was beyond the scope of this study, banana farming occupies around 30% of the agricultural land use in the Tully River catchment. It was a common refrain from farmers during our sampling that their sector seemed to be held continually under the spotlight in terms of concerns around improving reef water quality. Banana farms are within the purview of the Reef Regulations, are subject to investments in practice improvements, and the impact of banana farming is included in the reef water quality monitoring and improvement plans, however our sampling of cane farmers only contributed to their feeling of injustice during the sorting process, which may have influenced perceptions of the task. Notwithstanding, sampling the attitudes of banana farmers would objectively be worthwhile pursuit.

6.0 CONCLUSIONS

Having described the revealed discourses and discussed some tentative findings from the socio-demographic attributes of the members of each discourse (Covid-19 restrictions permitting), in the final section we make a series of recommendations that would support further work around communicating the key objectives and benefits of water quality trading markets to ensure a sustainable future for the sugar cane growing sector and regional economies in GBR catchments and to reduce the risks to the GBR from anthropogenic threats from land use and agricultural practices.

1. Once Covid-19 restrictions are lifted and in-person Q surveying can continue, further work should be undertaken to secure the data to test for statistically relevant correlations between socio-demographic attributes and factor membership and to generate robust data to submit our study to peer review through a relevant journal. Teasing out key differences between broad perspective pessimists and constructive optimists would be particularly useful. This sampling should also extend to the Lower Burdekin cane region at a minimum.
2. Statement 33, the need for clear attribution of nitrogen exports affecting water quality in rivers as a key motivation for improving on-farm nitrogen management, showed both a high level of congruence and a high level of salience across all four factors. This suggests that efforts to find creative and engaging ways to present scientific data directly connecting excess nitrogen applications with DIN levels in groundwater and rivers would assist in helping stakeholders consolidate knowledge around DIN impacts on the reef. Water quality experts in the field reflected on their own frustrations in this area. One respondent—somewhat tongue-in-cheek—stated (paraphrased) they wished they worked in grower engagement in the Burdekin region, as poor water quality is easier to demonstrate where sediment in rivers is the primary pollutant of concern. However, it is accepted that the science is difficult to effectively demonstrate clearly, even given the improved *in situ* water quality monitoring technologies that have recently been tested in the field. Online portals, showing real-time DIN loads (modelled or monitored) would prove very useful as an education tool. Furthermore, for a regulatory market to be trusted, it must demonstrate attribution to regulated entities, which requires further improvements in monitoring and reporting. This sentiment was particularly prevalent amongst business-as-usual sceptics and constructive optimists.
3. A significant cohort of scientific rationalists is established in cane growing regions through the NRM offices, such as Terrain in the Wet Tropics Region. NRM organisations and personnel have broad reach, are well-known and well-trusted in the community and have reasonable ‘convening power’. However, as yet, our results suggest that this cohort is not fully conversant in the application and potential benefits of economic mechanisms, such as water quality trading markets, both in terms of economic efficiency and in generating off-farm income for cane growers. This cohort could be useful advocates in driving awareness and uptake of water quality trading schemes, provided they can be convinced of the economic potential and practical feasibility of such approaches. It is noted that this conversation has already begun (Terrain NRM, 2019), although our findings suggest that further effort in this direction is probably required. It is relevant to note that there was no awareness from any farmer in our sample of the Reef Credits scheme run by Green Collar.

4. Two discourses, broad perspective pessimists and business-as-usual sceptics ranked S35 (efficacy of water quality trading) relatively lowly, at -4 and -3 respectively. Both these cohorts were dominated by farmers. In addition, qualitative feedback from respondents in both these cohorts cited the current implementation difficulties, in terms of transparency, prices and equity, of the Murray Darling Basin (MDB) water [quantity] trading market as the driver of their scepticism of water quality trading, as made apparent by the current Australian Competition and Consumer Commission inquiry into its functioning (ACCC, 2019) and significant media attention. Without judging the efficacy of the operations of the MDB water markets, it seems unlikely that markets for water *quality* will be supported by the agricultural sector until such time as perceived implementation issues with MDB water *quantity* trading are accepted as resolved by agricultural peak bodies.
5. There was a very high level of consensus between the four discourses for two statements associated with the longevity and security of any compensation contracts: S21 (the fixed term nature) and S22 (the long term nature) (see Table 9). However, sentiment was generally not strongly positive. This suggests that though the efficacy of water quality trading markets may be far from proven, their capacity to deliver long-term streams of (adequate) compensation payments to farmers will assist in take-up.

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