



Identifying innovation discourses for nitrogen management in the sugarcane sector in Great Barrier Reef catchments using Q-methodology

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ABSTRACT

Dissolved inorganic nitrogen (DIN) run-off from sugarcane farms along Australia's Great Barrier Reef (GBR) coast is implicated in poor catchment water quality and putting pressure on reef health. Reducing DIN is the focus of innovative policies to cut pollution and to maximize social benefit across economic sectors. We use Q-methodology to gain insight into discourses present amongst sugarcane sector stakeholders in GBR catchments. Issue statements, which we aligned with concepts from the Theory of Planned Behaviour, were ranked and correlations identified to generate factors that informed our descriptions of discourses. We found four discourse groups we called *sector stalwarts*, *scientific rationalists*, *economic maximisers*, and *sector defenders*. We also collected respondent demographic data from which we could judge the propensities of respondent groups to identify with different discourses. This information can help industry innovators and policymakers identify the attributes, mindsets, and appropriate language metaphors for engaging stakeholders in reducing catchment pollution.

1. Introduction

Agriculture has a long-established history in lowland areas of north-eastern Queensland, Australia, where catchments drain eastwards into the Great Barrier Reef (GBR). The impacts of pollutant run-off from agriculture are implicated in driving environmental degradation of the GBR (Robinson et al., 2016; Waterhouse et al., 2017). A key pollutant is dissolved inorganic nitrogen (DIN), caused by excess fertiliser applications (Brodie et al., 2012; De'ath et al., 2012; Kroon et al., 2012), which is linked to eutrophication of in-shore waters and to Crown of Thorns blooms, which can have more widespread impacts on the GBR ecosystem (Waterhouse et al., 2017). Policies and actions to reduce DIN run-off and improve water quality, through optimising on-farm practices and changes in land uses, will increase the ecological resilience of the GBR and support the reef's evident social, economic, and ecological values (Deloitte Access Economics, 2017; Stoeckl et al., 2011), particularly in light of the chronic, long term threat posed by climate change and other localised stressors, such as coastal development and over-fishing (as highlight in GBRMPA, 2019). However, to motivate the agriculture sector's engagement in programs to reduce DIN, policy and action needs to be balanced with efficiently sustaining agricultural

livelihoods, potentially through the implementation of innovative water quality trading schemes. This study seeks to provide evidence to affect this issue by seeking to reveal how the normative beliefs, sectoral attitudes, constraints, and discourses in the sugarcane sector can contribute to building constructive engagement between policy makers and the sugarcane sector.

To mitigate this pollution the sugarcane sector is subject to a complex policy framework. This involves all three tiers of government, industry peak bodies, and the involvement of industry-funded science and both the for-profit and not-for-profit sectors involved in land care — each with specific and often non-overlapping agendas (Brodie and Pearson, 2016; Commonwealth of Australia, 2015; Day and Dobbs, 2013) and differing degrees of “authoritative force” (Eberhard et al., 2021, p. 5) ranging from suasive instruments to incentive based schemes. This leaves sugarcane growers at the centre of myriad and competing messaging and regulatory regimes making their planning and decision-making subject to uncertainty and regulatory and reputational risk. Engagement in voluntary DIN loads mitigation schemes, such as the sector's own 6-Easy Steps (6ES) certification programme (Calcino et al., 2010b; Schroeder et al., 2010), have demonstrated some progress in reducing pollution but it remains challenging to reach and persuade

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sufficient growers to engage in the programme or to continue to further reduce nitrogen applications beyond 6ES in order to meet government targets set out in the *Reef 2050 Water Quality Improvement Plan 2017–2022* — a joint initiative by the Australian and Queensland governments that aims to improve the GBR water quality by reducing sediment, fertiliser, and pesticide runoff (Commonwealth of Australia and Queensland Government, 2018). This challenge has been taken-up by research through the Australian Commonwealth-funded National Environmental Science Program’s Tropical Water Quality Hub (<https://nesptropical.edu.au>), which is seeking to understand growers’ motivations to engage in additional incentive-based schemes, such as water quality trading and compensation-based schemes, and in refraining from dis-adoption of improved practices once engagement, or financial support has ceased. Similar market-based policy instruments are noted for the cost effectiveness and have deployed in the USA and the European Union (Greenhalgh and Selman, 2012; Morgan and Wolverton, 2005; Star et al., 2021).

Grower engagement in pro-environmental behaviours 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). Externally, common barriers to participation in practices that support broader public good outcomes are the potential for lost productivity and limits to future land-use options (Moon and Cocklin, 2011). Grower responses to agri-environmental schemes, which provide payment for behaviour change (better environmental outcomes, for example), are predicated on the assumption that growers will act when the compensation payment exceeds the anticipated reduction in profit (Windle and Rolfe, 2005), including transaction costs, which can represent more than a third of total funding made available (Coggan et al., 2015).

Whilst adequate financial incentives are necessary, they have proved insufficient in driving adequate adoption of modified behaviours. Internal drivers also play a role (Rolfe and Harvey, 2017; Rolfe et al., 2018). Behaviour change, and sustaining that change, is reliant on shifts in values and social norms (Grube et al., 1994). Our study is informed by concepts from the Theory of Planned Behaviour (ToPB) (Ajzen, 1985),

similarly applied in relevant studies inquiring into sustainability (Fielding et al., 2008; Klöckner, 2013) and farmer motivations for behaviour change, including in the GBR region (Ansari and Tabassum, 2018; Hasan et al., 2021; Zeweld et al., 2017). The ToPB posits that intentions (and therefore subsequent behaviours) are contingent on an interplay of *attitudes*, *perceived behavioural controls*, and *subjective norms* (Fig. 1).

Attitudes include an agent’s perceptions of a change’s usefulness and compatibility, and from a problem awareness and have both emotional and cognitive components. Perceived behavioural controls are external factors that hinder, control, or promote intentions and are based in an agent’s perceived ability and capability (beliefs) to perform the behaviour. Subjective norms are factors related to the judgement of others and the role of the media, peers, training, and extension services in framing discourse.

Subjective norms, including conceptions of *what others like me are doing*, and personal moral codes are predictors of pro-environmental behavioural intention and consequent behaviours (Fielding et al., 2008; Klöckner, 2013; Zeweld et al., 2017). Social norms and social verification are also known to be drivers of grower behaviour, either for or against improved practices, particularly in tight-knit communities, such as the sugarcane grower community, and where there is also an influential peak body (the CaneGrowers Association). For example, Hasan et al. (2021) showed that growers were less likely to change fertiliser practice if they regarded maintaining good relationships with other local growers as being extremely important. Problem awareness is also shown to be an important, but only as an indirect determinant of pro-environmental intention (Bamberg and Möser, 2007), though “pro-environmental stewardship values” can often be starting from a place of only “minor influence” in Australia (Cary et al., 2002, p. ix). Finally, demographic attributes, such as age, can be a factor in resisting change in practices (Fenton et al., 2000) but other studies point to the role of additional experience that age brings in adopting new behaviours (Anosike and Coughenour, 1990; Hasan et al., 2021). Thus, we hypothesise that understanding attitudes, subjective norms and perceived behavioural controls in the sugarcane sector is useful for

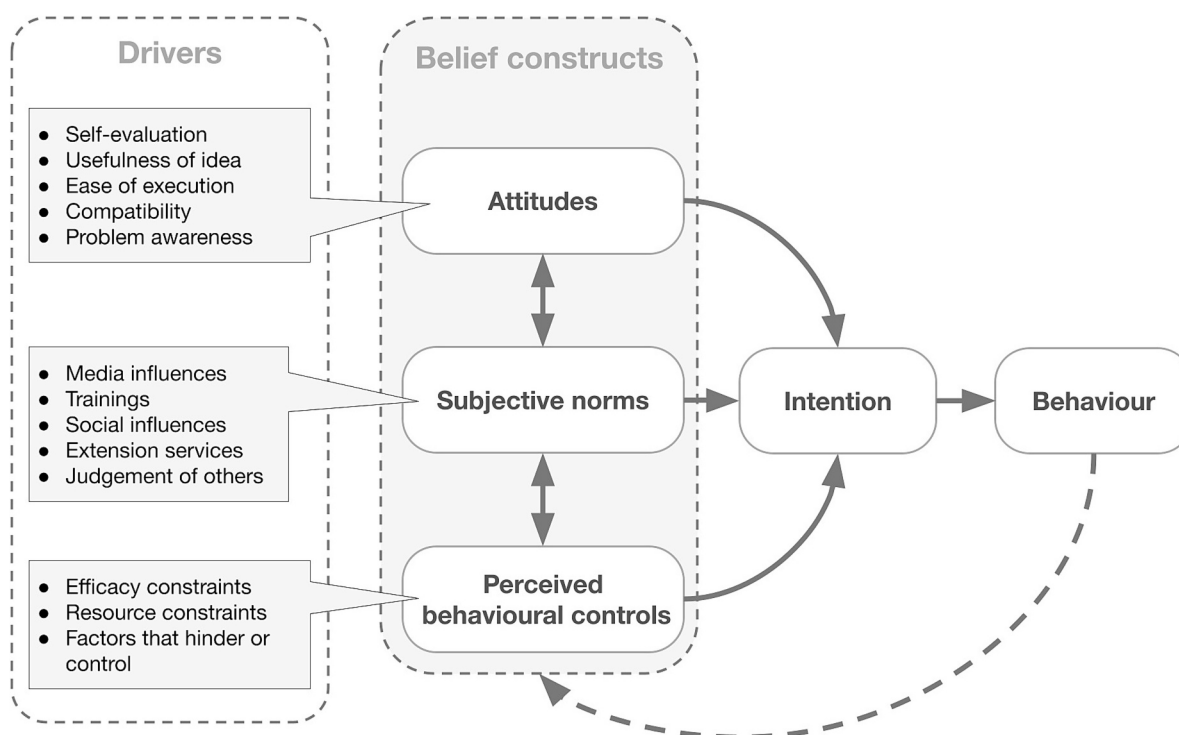


Fig. 1. Mental model for determining for classifying statements to belief constructs of the Theory of Planned Behaviour (based on Ajzen, 1985).

predicting the likelihood innovative, incentive-based schemes required to deliver the water quality targets for the GBR will be taken-up by growers and supported across the sector.

The objective of our research was to reveal the key discourses present amongst stakeholders associated with the sugarcane sector in GBR catchments. We also sought answers to two secondary questions: (a) which discourses are most associated with positive attitudes towards innovation and would encourage a higher likelihood of association with participants in such schemes; and (b) which socio-demographic attributes have a greater propensity to align with the discourse groups most sympathetic to innovation. 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 attitudes towards regulation and private property can provide valuable insight into the potential for acceptance of innovative compensation schemes amongst sugarcane growers.

We used Q methodology (hereafter: Q) to identify the range of perspectives held on such schemes in the sugarcane sector. Q is a qualitative survey method (Stenner and Stainton Rogers, 2004) based on statistical analysis of a person's subjectivity, expressed through the ranking of issue statements (Stephenson, 1953). Q has proven suitable for agricultural management and policy appraisal, having been used to reveal insight into whether a policy mechanism will be accepted (Zabala et al., 2018), but has only been used sporadically in the study of discourses in pollution-related practice change and land use. For example, Kerr and Bjornlund (2018) identified four farming discourse groups in relation to pollution mitigation in Canada: (i) *incentive orientees*; (ii) *rural advocates*; (iii) *honest brokers*; and (iv) *progressive producers*. Incentive orientees were the innovators — they saw regulations as blunt instruments and saw market-based instruments as the best way of enabling improved water quality, accompanied by a viewpoint that 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 their 'moral code' of (self-determined) stewardship. Honest brokers (generally not producers) tended to fit the 'administrative rationalism' discourse (as described by Dryzek, 1997). Finally, progressive producers also could be identified as predisposed to innovation, however they framed their discourse generally from a position of market power and influence: they were already producers working to high standards in capital intensive operations. They, too, were sceptical of subsidies. In another example, Buckley (Buckley, 2012) used Q to investigate post-policy implementation attitudes towards abatement of nitrogen pollution in Ireland. Buckley also identified four discourse groups: (i) *constrained productionists* who were private property-focused and sceptical of measures to improve water quality; (ii) *concerned practitioners* who shared these concerns but were generally more positive about policy change; (iii) *benefit acceptors* who were environmentally focussed and positive towards the purpose of and the implementation of the regulations; and (iv) *regulation unaffected* who are unaffected by policy and remained indifferent. Outside Q, Simmons et al. (2020), using factor analysis of survey data, 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*. Long form interviews (n = 8) by Oza et al. (2021), starting from a socio-ecological systems perspective, identified concerns specific to our Q cohort related to concerns over long term profitability, the loss of property rights (being subject to greater regulation) and support for the retention of important habitats (mangroves) on private land, but only in conjunction with financial consideration for managing private land for public goods.

Our study expected to reveal broadly corresponding discourse groups, particularly in terms of revealing a gradient of sentiment from acceptance of further compliance measures and an openness to

innovation towards more a property rights-dominant perspective with reservations about the need for further regulation, in this instance, related to belief in the connection between fertiliser use, poor water quality, and GBR health. Our study builds on the corpus of knowledge around engagement of the agricultural sector in incentive-based schemes, more generally, and amongst sugarcane growers in GBR catchments specifically (Calcino et al., 2010a; Gooch et al., 2018; Rolfe and Harvey, 2017).

2. Context of study

There are approximately 4000 sugarcane farming entities in Queensland, growing on ~380,000 ha (Fig. 2). The sector generates significant economic benefit to regional Queensland and is an important aspect of local cultural identity and a major shaper of the physical landscape and its infrastructure (Griggs, 2011; Johnston, 1988; QFF, 2020). The presence of the GBR is also a crucial regional driver of employment. It is estimated to support around 58,000 jobs, particularly in the recreation and tourism sectors, and contribute over \$5.4 billion to Australia's annual GDP (Deloitte Access Economics, 2017). In addition, the GBR provides significant ecosystem service benefits, including wild fisheries, coastal protection from storm surge, and carbon sequestration in its mangroves and sea grass beds (Deloitte Access Economics, 2017; Stoeckl et al., 2021; Waycott et al., 2005). Non-economic values and cultural values to the region's Indigenous Peoples are also significant (De Valck and Rolfe, 2022; Deloitte Access Economics, 2017, ch. 4).

Our study data were collected in the Wet Tropics Natural Resource Management region of north Queensland, around the towns of Tully and Ingham. This region is characterised by rain dependent sugarcane growers on coastal plains with catchments containing fast flowing, relatively short, and permanent rivers flowing into the GBR lagoon. These lagoon waters are warm and sunlit and subject to water quality issues related to DIN loads, more fully described in the 2017 *Scientific Consensus Statement* (Waterhouse et al., 2017). Sugarcane farms in these catchments tend to be small, family-owned operations, between 40 and 250 ha (Canegrowers, 2017). Frequently, growers manage land on behalf of older, retired, or semi-retired growers (Canegrowers, 2017). This region is subject to the Queensland Government's Wet Tropics Major Integrated Project (MIP), which seeks to reduce pollution into waterways through encouraging growers to adopt best management practices (BMP) and accessing market-based schemes, such as earning 'Reef Credits', a type of payment for ecosystem services (GreenCollar, 2019; Queensland Government, 2020).

Data collection was carried out during an important juncture in GBR pollution policy, which would have likely influenced respondent preferences. Firstly, in September 2019, the Queensland Government legislated *The Environmental Protection (Great Barrier Reef Protection Measures) and Other Legislation Amendment Bill 2019* (colloquially known as the 'Reef Regulations'), which, for the first time, imposed caps on DIN, sediment, and pesticide emissions in GBR catchments and set minimum practice standards for agriculture, including sugarcane, bananas, and cattle grazing. The legislation was controversial and not politically bipartisan, with numerous media reporting a sense of "demonisation" of the agricultural sector (ABC News, 2019b). The CaneGrowers Association 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 (CaneGrowers, 2019a; The Guardian, 2019). This reflected a 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 was that the GBR condition be downgraded from 'poor' to 'very poor', that water quality targets were not being met, and that poor agricultural land management practices are the greatest contributor to poor water quality. Thirdly, in the 12 months prior to the

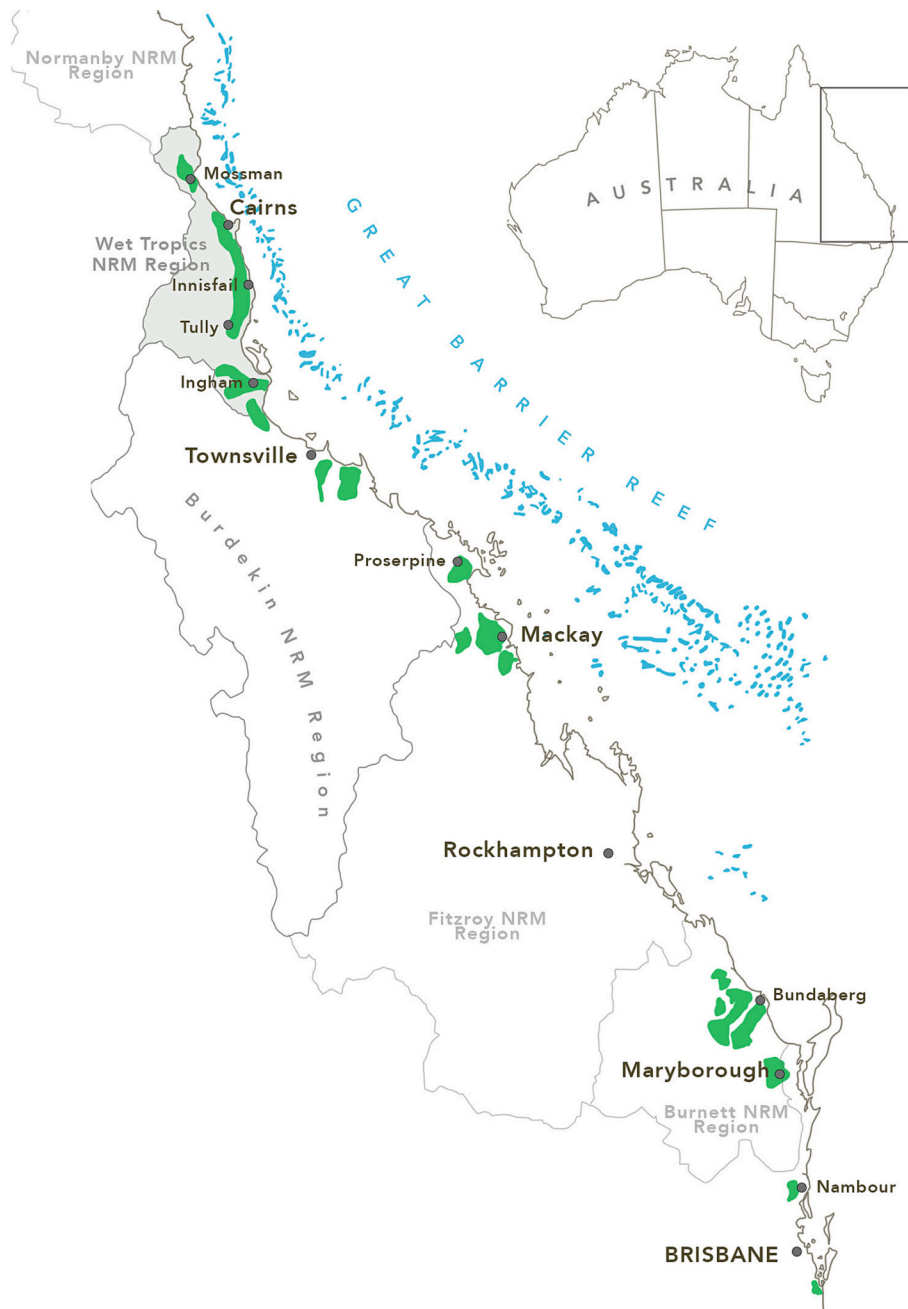


Fig. 2. Map of study area in the context of the broad sugarcane growing areas, including our case study area, the Wet Tropics NRM region, and the proximity of the Great Barrier Reef.

study, the Commonwealth Government had made a significant investment in the GBR by granting a relatively modest organisation, the Great Barrier Reef Foundation, a donation of AU\$ 450 million towards projects that support GBR protection and restoration (ABC News, 2019a). Contemporaneously, the prospect of the new legislation limiting pollution had prompted significant organisational innovation in how the water quality targets might be achieved, including the use of Reef Credits. This convergence of environmental drivers, research backing, policy advances, and legislative change created an environment ready for innovation, particularly in support of water quality improvement and using market-based mechanisms (DEHP, 2014; Smart et al., 2016).

3. Method

Q combines quantitative analysis of respondent preferences with

inductive reasoning by the analyst about the intent of the respondent, in this instance, implicitly informed by ToPB concepts. Q demands abductive reasoning, whereby researchers seek the most likely conclusions from an incomplete set of observations (Langston et al., 2019, p. 5). In operation 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 (Dryzek, 1994, 1997). Discourses are both external to individuals (they act on people) but are also emergent of collective heuristics of groups of people, based on shared, world experiences (people and power structures actively shape them) (Gregory, 1978; Robbins and Krueger, 2000). An important assumption behind Q is that there are always a limited number of perspectives that exist in a group of people on any given topic; 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 (Barry and Proops, 1999).

We followed a method consistent with phases common in the Q literature (Donner, 2001; Dziopa and Ahern, 2011; van Excel and de Graaf, 2005). The first stage was to define the scope of the study and the respondents (the P-set). Selecting a diverse P-set provides opportunity to uncover more diverse viewpoints (Nguyen et al., 2018; Webler et al., 2009) and, in this instance, to also test views of those outside the target of actual behaviour change. Our P-set (Table 1) comprised (i) sugarcane growers (including contractors); (ii) agricultural extension and peak body representatives; (iii) natural resource managers and scientists; and (iv) related private sector.

The scope of the issues from which the statements are drawn is referred to as the *concourse* — the sum of things people *say* and *think* about a particular issue. This was generated through deliberative, mixed-method approaches (Kenter et al., 2016; Kenter et al., 2011) through the following activities. Firstly, draft statements were generated from existing literature reviews, stakeholder interests (including the Queensland Government), and prior informal interviews with growers and peak body representatives in the sugarcane sector. Secondly, from this *concourse*, draft statements were piloted with five respondents prior to further work on refining to final statements. The final statements are listed in Table 3 (reported in the results section) with justifications for statement inclusion made in Supplementary Table 1. Finally, each statement was aligned with three pre-intentional belief constructs from the ToPB (perceived behavioural control, attitude, and subjective norm) to help inform later subjective interpretation of candidate factors (again listed in Table 3). This process determined the statements as follows: 9 perceived behavioural control, 15 attitude, and 12 subjective norms. Note that in each instance, a statement may either positively support a given control, attitude, or norm, or constrain it.

Operationally, Q facilitates the ranking of statements to a respondent onto a quasi-normal grid in order of salience. The fewer placements at the extremes makes the respondents think most carefully about which statements are the most or least salient. In this instance, our grid contained placements from +5 to -5, including zero, for 36 statements. Respondents are also encouraged to ‘think out loud’ and explain their decisions. Substantive data collection was carried out in January 2020 and in March 2021 in the Tully and Ingham areas of North Queensland (taking account of the travel restrictions in place due to the Covid-19 pandemic). Data collection took place over two periods of three days by a team of three. Recruitment and surveying of respondents was undertaken with the assistance of staff at the offices of the Terrain NRM, which had been tasked with managing the region’s MIP. The majority of growers’ sorts were carried out on their farms.

Statistical analysis of the sorts was undertaken with the desktop application KADE (Banasic, 2018). We calculated the correlations between the participants’ Q sorts to create a ‘correlation matrix’, which was then subject to factor analysis using Principle Component Analysis. Four factors explained 48 % of the total variation in the sorts, which

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

Stakeholder group	Sample identifying as	Number of respondents identifying as*
Farmer	Sugar cane farmers in Tully and Ingham areas	25
Farming contractor	Farming contractors who manage other’s farms	5
Agricultural extension	Wet Tropics Major Integrated Projects Team, Canegrowers Association	9
Science/NRM	Sugar Research Authority, Terrain NRM	8
Others	Business	1

* Note this column totals 48 and the number of respondents was 44. Some respondents identified as both farmers and contractors and farmers and extension officers.

exceeds the threshold of 35 %–40 % for Q, as suggested by Kline (1994). Results are reported in Table 2. These four factors were retained for Varimax rotation. Respondents were assigned to the rotated factors with *p*-value of <0.05. Of the 44 respondents, 37 loaded on to a rotated factor. Seven respondents were either confounding or did not load into any factor and were discarded. These sorts are still included in the analysis of consensus statements and low-scoring statements.

The final step was to consider the ‘ideal sort’ of each factor. The ideal sort reflects a hypothetical respondent whose views would load 100 % on to that factor. We used the ideal sorts to generate a common language description, or discourse. This discourse provides rich, contextual insight into the dominant perspectives with which respondents are then aligned. When analysing the ideal sorts, we placed greater emphasis on the most highly and lowly ranked statements (indicated by their *z*-score), statements placed significantly differently in one factor when compared to all others, and salient explanations provided by the respondents during their sorting exercise.

4. Results

The statement rankings for our four factors are reported in Table 3. The ideal sorts are shown in Figs. 4 to 7 below. We mapped the three core belief constructs of ToPB (*attitudes*, *subjective norms*, and *perceived behavioural controls*) and scored each statement based on the relative strength of the placement and whether it was ranked significantly higher or lower than other factors. The output of this exercise is in Fig. 3.

4.1. Factors and discourses

Our interpretation of the ideal sorts of the four factors is also set out below. We determined to name our four discourses: (i) sector stalwarts; (ii) scientific rationalists; (iii) economic maximisers; and (iv) sector defenders. Through the following sections the following syntax conventions apply: ‘significantly higher/lower’ means the statement is ranked differently to all other factors with a *p*-value of equal to or <0.05; and ‘very significantly higher/lower’ means the statement is ranked differently to all other factors with a *p*-value of less than or equal to 0.01. To assist the reader and to ease cognitive load, with the reasoning behind our descriptions of the factors, when we refer to a statement we provide a shorthand description and the statement number (S), which should be cross-referenced with the full statement in Table 3. Direct quotes from respondents are in double quotes.

4.1.1. Discourse 1: sector stalwarts

This discourse group sees a strongly positive role for the sugarcane sector that is well-managed, informed, and important to the region. Positively placed statements were weighted towards subjective norms, with little priority given to statements reflecting *perceived behavioural controls*. Negatively placed statements are shared across all three concepts from the ToPB. This suggests the group is strongly influenced by discourses promoted through the media, extension services, training, and by their peers. But also feels a fair degree of autonomy, free from behavioural controls. This factor was most similar is factor 3 (0.4818 correlation) and least similar factor 2 (0.3269) (see Table 2).

This discourse group generally accepts the science linking GBR health back through water quality issues and DIN emissions but is indifferent to innovative policy mechanisms in meeting the challenge of managing emissions. S32 (agriculture is mainstay of the region’s economy) was ranked most strongly; S25 (looking after the soil) was ranked at +4; and S10 (agriculture can have a broad positive impact) is ranked at +3. This group is somewhat sympathetic to environmental issues and has constructive attitudes towards practical measures to achieve environmental outcomes. S16, (growers have responsibility to improve water quality and the environment) was ranked at +4, and they believed well-managed agriculture can have a positive impact on the environment and the economy (S10 ranked +3). This discourse group is little

Table 2

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 respondents associated with factor	Correlations between factor scores			
				Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	10.70	24	11	1	0.3269	0.4818	0.3638
Factor 2	4.84	35	12		1	0.1519	0.1624
Factor 3	3.02	42	8			1	0.4086
Factor 4	2.81	48	6				1

concerned about whether the risk to GBR from agricultural run-off is over-stated (S14 ranked at -1). Given this only guarded support of the scientific consensus, it was surprising S33 (growers would be more inclined to act if they could see direct evidence) was ranked so positively, at $+3$. One respondent stated, “if growers could see that nitrogen was coming directly off their paddocks, I believe they would change tomorrow”, 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 allegedly moved, which would have affected the DIN emissions data. This discourse group has a slightly pessimistic view of the future of sugarcane farming, ranking S27 (cane farming offers a rewarding future) at -3 and S29 (making a living from cane farming is hard, but leaving is harder) was ranked at $+3$, very significantly higher than all other discourses. There is also a pessimism around the viability of technologies, such as constructed wetlands, being a solution (S26; ranked at -3).

Statements related to Reef Regulations were ranked ambivalently. However, S2 (Reef Regulations expose growers to unnecessary risks) was ranked very significantly higher than all other discourse groups, but only at -1 . The efficacy of water quality trading systems (S35) was ranked at -4 , very significantly lower than other discourse groups; and the availability of a fixed term trading contracts would make little difference (S21 was ranked at -3 , very significantly lower than all other discourse groups). A number of respondents in this group linked their own scepticism with recent and generally unfavourable media coverage of the functioning of the Murray-Darling water allocation trading scheme and Australia’s history of carbon pricing schemes between 2012 and 2014. There is also strong concern that if water quality offset schemes reduced sugarcane production there would be significant long term value chain impacts, with lower demand for farming contractors and agricultural inputs and, ultimately, unviable mills. It was argued that if milling throughput fell below a threshold and led to mill closure, the regional prospect for sugarcane would be put in jeopardy. Attitudes towards agricultural extension programmes are positive (S23 ranked $+2$), however, one respondent stated that they felt compensation packages needed to be more “solutions-based” and had historically been “poorly targeted”. This discourse group does not see a role for Indigenous People, nor traditional knowledge in landscape management: S18 and S19 were ranked at -5 and -4 respectively, significantly lower than all other discourse groups.

For these reasons, we determined to label this group *sector stalwarts*. Only men, who were virtually all growers and farming contractors aligned with this discourse. Of those who reported land holdings, this cohort had, on average, smaller properties and slightly less experience than factors 3 and 4 (the only other discourses that were mostly growers). The ideal sort for *sector stalwarts* is represented in Fig. 4.

4.1.2. Discourse 2: scientific rationalists

The second discourse group has a strong scientific focus and preference for issues associated with environmental management. There was very strong salience given to *attitude* statements and no importance given to *perceived behavioural control* statements. Conversely, statements given a low level of salience, or considered not important were dominated by *perceived behavioural control* statements, with no *attitude*

statements at all. This points to this group having strong views associated problem perception, seeing a clear pathway to policy solutions, and having no regard to any behavioural controls that would hinder any change in practice. *Social norm* statements were also much less important in both strongly positive and negatively ranked statements. This factor was most similar to factor 1 (0.3269) and very dissimilar to both factor 3 (0.1519) and factor 4 (0.1624) (see Table 2).

This discourse group ranked S8 (poor water quality in rivers is damaging the reef) at $+4$, very significantly higher than all other discourse groups; S16 (growers have a responsibility to reduce impact on water quality) at $+3$; and S9 (agriculture has impact on water quality in rivers) at $+2$ (very significantly higher than other discourse groups). S28 (landscape management is a shared financial responsibility) was also ranked very significantly higher at $+3$, suggesting, whilst this discourse group believes that the community should bear *some* of the costs of improving water quality, it is the responsibility of the grower to engage with the processes and institutions that enable this to happen — and growers have not traditionally been good stewards of the land and environment (S13 ranked at -2 , very significantly lower than all other discourses). The highest ranked statement was S25 (looking after the soil), however, this statement received both broad consensus and high salience from all discourse groups. This sentiment was further underlined by respondent comments alluding to concepts of “holistic farm management” and “connecting stewardship of the environment with stewardship of the farm”. One respondent said, “if you are negatively impacting the environment, you will be negatively affecting your farm” and another said that growers should “work *with* the environment, not *against* it”. This discourse group was the only one to rank the risks of climate change to agricultural production with any prescience, ranking S12 significantly higher than all others at $+3$. This discourse group ranked the two statements (S18 and S19) associated with Indigenous Peoples’ involvement in landscape management generally higher than other groups. Combined, this was the only discourse group to rank these two statements positively, reflecting an appreciation of the growing scientific corpus recognising the role of traditional land management in Australia (Ogar et al., 2020).

The low-ranking statements were *perceived behavioural control*-related statements. The lowest ranked was S1 (growers should be able to manage their land as they see fit), demonstrating a strong salience with the need for regulation. S14 (risk to the reef is overstated by the media) was ranked significantly lower than others at -3 . This group believed the environment is not prioritised over the agricultural sector (S5 was ranked at -4 , very significantly lower); that sugarcane growers can meet the Reef Regulations with limited risk from competition (S17 was ranked at -4 , significantly lower than others); and that these regulations are reasonably well communicated (S3, ranked -2). One respondent stated, “the reef regs [regulations] are a pretty low bar and shouldn’t stop growers making money”.

Despite the generally rationalist perspective, this discourse group did not have strong salience with the statements associated with the incentive schemes and an ambivalence towards the two contract-based statements (S22 — availability of long-term contracts and S21 — fixed term compensation contracts can persuade growers to engage). One respondent (an extension officer) explained that providing financial

Table 3
Summary results for our Q-method showing statement ranks and z-score for Factors 1, 2, and 3.

			Factor 1		Factor 2		Factor 3		Factor 4	
			Rank	z-Score	Rank	z-Score	Rank	z-Score	Rank	z-Score
1	Farmers should be free to manage their agricultural operations as they see fit; with much less much interference from government.	Perceived behavioural control	-0.79	29	-1.55	36	-1.45	33	0.63	13
2	The new Reef Regulations for the agricultural sector expose landholders to unnecessary financial risk in planning their operations.	Perceived behavioural control	0.26	13	-1.19	32	-0.51	24	-1.14	31
3	The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	Perceived behavioural control	0.92	8	-0.88	28	0.13	19	-0.5	21
4	Cane growers are sufficiently kept up-to-date about the requirements of farming regulations.	Attitude	-0.44	25	-0.51	23	0.38	14	-0.17	20
5	The environment needs to be balanced with the needs of the agricultural sector. At the moment, it feels like environmental concerns are dominant.	Perceived behavioural control	0.14	16	-1.54	35	0.27	16	0.97	8
6	The sugar cane sector needs a shake-up. It risks losing the trust of the community if it doesn't change.	Subjective norm	-0.89	30	-0.49	22	-2.22	36	-1.91	36
7	It is likely most cane growers in this area will abide by the new Reef Regulations.	Subjective norm	0.93	7	0.29	15	0.21	18	0.6	15
8	Poor water quality in our rivers flowing into the Great Barrier Reef Marine Park is damaging the reef environment.	Attitude	0.54	10	1.41	2	-1.06	31	-0.7	24
9	Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.	Subjective norm	-0.02	21	0.81	10	-1.95	35	-1.51	35
10	Agricultural land uses, when well-managed, can have a positive impact on the both the environment and the local economy.	Attitude	1.26	4	1.4	3	1.24	3	1.5	1
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.	Attitude	-0.01	20	1.14	7	-0.27	22	0.33	19
12	Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	Attitude	-0.78	28	1.37	5	-1.24	32	-1.3	33
13	Australia's agricultural and grazing sectors have traditionally been good stewards of the land, nature, and the environment.	Subjective norm	0.19	15	-0.89	29	0.55	13	1.08	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.	Subjective norm	-0.31	24	-1.46	33	1.1	6	1.03	6
15	Maintaining the agricultural productivity of sugar cane in the long term is the biggest challenge for the sector in Far North Queensland.	Perceived behavioural control	0.19	14	-0.23	19	1.19	4	0.6	16
16	Farmers have a responsibility to reduce the impact of farming on water quality and the environment.	Subjective norm	1.4	3	1.19	6	1.16	5	0.43	18
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.	Perceived behavioural control	0.06	18	-1.47	34	-0.06	21	-0.84	27
18	Landscape management (caring for country) in our region would benefit from a greater inclusion of Indigenous and Traditional Knowledge.	Subjective norm	-1.96	36	0.76	11	-0.76	28	-0.6	23
19	Managing wetlands and landscapes for environmental outcomes can play an important role in providing employment for Indigenous People.	Attitude	-1.64	34	0.25	16	-0.54	27	0.91	10
20	Farmers should be compensated for their time spent and for capital investments needed to improve practice change beyond Canegrowers' 'Six Easy Steps' standards.	Attitude	-0.62	27	-0.43	21	0.35	15	-1.01	29
21	A fixed-term compensation contract would be enough to persuade cane farmers to change practice to go beyond the Reef Regulations for fertiliser management.	Attitude	-1.2	32	-0.25	20	0.75	9	-0.53	22
22	A long-term contract could offset both the costs and risks of permanently converting a cane paddock to wetlands.	Attitude	-0.62	26	-0.2	18	0.22	17	-1.01	28
23	Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and staying profitable.	Subjective norm	0.57	9	0.69	12	0.69	11	1.41	2
24	Higher levels of agricultural productivity can be sustained through adopting new technologies.	Attitude	0.09	17	0.31	14	0.85	8	0.9	11
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.	Attitude	1.83	2	2	1	1.85	1	1.12	4
26	Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	Perceived behavioural control	-1.01	31	-0.7	27	-0.8	29	-1.13	30
27	Cane farming offers a rewarding future for the next generation of growers.	Subjective norm	-1.23	33	-0.59	24	-1.68	34	1.26	3
28	Landscape management and protection of habitat on private property is a shared financial responsibility of the community and the landholder/farmer.	Subjective norm	-0.27	23	1.39	4	-0.52	26	0.48	17

(continued on next page)

Table 3 (continued)

			Factor 1		Factor 2		Factor 3		Factor 4	
			Rank	z-Score	Rank	z-Score	Rank	z-Score	Rank	z-Score
R29	Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	Subjective norm	1.25	5	-0.6	25	-0.34	23	-0.78	26
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.	Perceived behavioural control	0.46	11	-0.91	30	-0.87	30	0.92	9
31	Cane growers would convert some of their low yield land to wetlands, if it was more profitable than growing cane there.	Attitude	0.03	19	0.62	13	0.11	20	-0.72	25
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.	Subjective norm	2.3	1	0.96	8	1.47	2	0.6	14
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.	Attitude	1.03	6	0.87	9	0.96	7	0.68	12
34	The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.	Perceived behavioural control	-0.17	22	-1.08	31	0.73	10	-1.38	34
35	A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	Attitude	-1.92	35	-0.64	26	0.56	12	-1.2	32
36	The new Reef Regulations are a blunt instrument for achieving better water quality outcomes. Industry BMP provides a more flexible route to improvements.	Attitude	0.42	12	0.16	17	-0.52	25	0.98	7

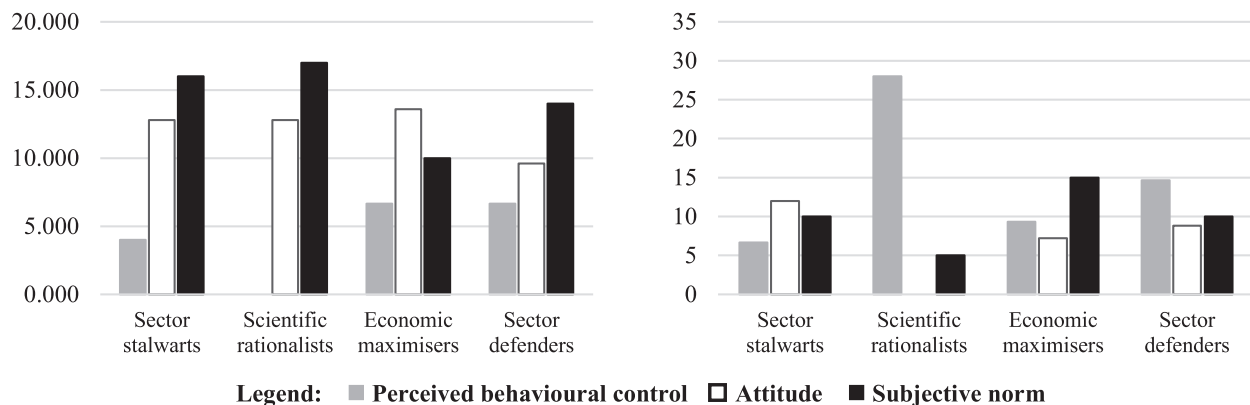


Fig. 3. Alignment of our four discourses with concepts from the Theory of Planned Behaviour. Fig. a (left): relative score of all positively placed statements; Fig. b (right): relative score of negatively placed statements. The following scoring system is used: +5 = 5, +4 = 4, +3 = 3, +2 = 2, and any remaining distinguishing statements ranked higher was scored as 1 and -5 = 5, -4 = 4, -3 = 3, -2 = 2, and any remaining distinguishing statements ranked lower was scored as 1. The scores are normalised to provide equal weighting to each of the concepts.

compensation for restricting sugarcane production fundamentally misunderstands growers' psychological motivations, which are not *only* influenced by economic maximisation. Instead, engagement should still focus on "production", but "production of ecosystem services".

We labelled this discourse group *scientific rationalists*. This group had the largest number of members (12); had the only significant cohort of women (it was split six men and six women); was the youngest (mean: 43 years old); and had the fewest years of experience (mean: 20 years). Occupationally, this group was dominated by agricultural extension and science officers, however, it still contained three growers. The ideal sort for *scientific rationalists* is represented in Fig. 5.

4.1.3. Discourse 3: economic maximisers

This discourse group is confident in the significant role and the positive impact the sugarcane sector plays in the region. Positively placed statements were dominated by *attitude* statements, with few *perceived behavioural controls*. Negatively placed statements had little partiality. This suggests this discourse is motivated more by the self-perceptions of problems and the compatibility of their likely solutions, intentions, and behaviours and less by structural controls and *subjective norms*, such as general and shared sentiments within the sugarcane

sector and support services. This factor was most similar to factor 1 (0.4818) and least similar to factor 2 (0.1519) (see Table 2).

This discourse group firmly believed sugarcane was the mainstay of the economy (S32 ranked +4) and that well-managed agriculture has a positive impact on the environment (S10 ranked +4). This group is confident the sector is not at risk of losing its trust in the community (S6 ranked -5) but, despite the central importance of the sector, they are pessimistic about its future (S27 ranked -4, significantly lower than other discourses). The discourse group is sceptical of many aspects of the science that links agricultural run-off with poor river water quality, which risks GBR health and of the impacts of climate change but nevertheless would take advantage of opportunities to diversify farm income by accessing water quality trading, compensation, or offset schemes. For example, this discourse group ranked S9 (cane operations have a negative impact on water quality) at -4; S8 (poor river water quality is damaging the reef environment) at -3; S14 (the risk to the reef is overstated in the media) at +3; and the risks from climate change (S12) was ranked at -3. A repeated message by respondents in this group was the belief that agricultural run-off *might* have an impact on the "inner reef", but *not* on the "outer reef", which they see as being important to the tourism sector — the inner reef was erroneously not

-5	-4	-3	-2	-1	0	1	2	3	4	5
** ◀ 18. Landscape management (caring for country) in our region would benefit from a greater inclusion of Indigenous and Traditional Knowledge.	** ◀ 19. Managing wetlands and landscapes for environmental outcomes can play an important role in providing employment for Indigenous People.	26. Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	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.	5. The environment needs to be balanced with the needs of the agricultural sector. At the moment, it feels like environmental concerns are dominant.	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.	7. It is likely most cane growers in this area will abide by the new Reef Regulations.	10. Agricultural land uses, when well-managed, can have a positive impact on the both the environment and the local economy.	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.
	** ◀ 35. A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	** ◀ 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.	* 12. Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	28. Landscape management and protection of habitat on private property is a shared financial responsibility of the community and the landholder/farmer.	24. Higher levels of agricultural productivity can be sustained through adopting new technologies.	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. The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	** ▶ 29. Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	16. Farmers have a responsibility to reduce the impact of farming on water quality and the environment.	
		* 27. Cane farming offers a rewarding future for the next generation of growers.	** 1. Farmers should be free to manage their agricultural operations as they see fit, with much less much interference from government.	** 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 fertilizer applications to meet the new Reef Regulations, they will lose out to international competitors, who can use as much fertilizer as they want."	2. The new Reef Regulations for the agricultural sector expose landholders to unnecessary financial risk in planning their operations.	** ▶ 23. Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and staying profitable.	** ▶ 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.		
			6. The sugar cane sector needs a shake-up. It risks losing the trust of the community, if it doesn't change.	4. Cane growers are sufficiently kept up-to-date about the requirements of farming regulations.	31. Cane growers would convert some of their low yield land to wetlands, if it was more profitable than growing cane there.	13. Australia's agricultural and grazing sectors have traditionally been good stewards of the land, nature and the environment."	** 8. Poor water quality in our rivers flowing into the Great Barrier Reef Marine Park is damaging the reef environment.			
				22. A long-term contract could offset both the costs and risks of permanently converting a cane paddock to wetlands.	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.	15. Maintaining the agricultural productivity of sugar cane in the long term is the biggest challenge for the sector in Far North Queensland.				
					** 9. Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.					

Fig. 4. Ideal sort for *sector stalwarts* (from factor 1). 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.

-5	-4	-3	-2	-1	0	1	2	3	4	5
1. Farmers should be free to manage their agricultural operations as they see fit, with much less much interference from government.	** ◀ 17. If Queensland cane farmers have to reduce their fertilizer applications to meet the new Reef Regulations, they will lose out to international competitors, who can use as much fertilizer as they want."	34. The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.	26. Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	6. The sugar cane sector needs a shake-up. It risks losing the trust of the community, if it doesn't change.	** 19. Managing wetlands and landscapes for environmental outcomes can play an important role in providing employment for Indigenous People.	** ▶ 18. Landscape management (caring for country) in our region would benefit from a greater inclusion of Indigenous and Traditional Knowledge.	** ▶ 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.	** ▶ 28. Landscape management and protection of habitat on private property is a shared financial responsibility of the community and the landholder/farmer.	** ▶ 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.	2. The new Reef Regulations for the agricultural sector expose landholders to unnecessary financial risk in planning their operations.	3. The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	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.	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.	** ▶ 12. Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	10. Agricultural land uses, when well-managed, can have a positive impact on the both the environment and the local economy.	
		** ◀ 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.	** ◀ 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.	22. A long-term contract could offset both the costs and risks of permanently converting a cane paddock to wetlands.	* 31. Cane growers would convert some of their low yield land to wetlands, if it was more profitable than growing cane there.	** ▶ 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.	** ▶ 16. Farmers have a responsibility to reduce the impact of farming on water quality and the environment.		
			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.	29. Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	* 15. Maintaining the agricultural productivity of sugar cane in the long term is the biggest challenge for the sector in Far North Queensland.	24. Higher levels of agricultural productivity can be sustained through adopting new technologies.	** ▶ 9. Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.			
				* 35. A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	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.	7. It is likely most cane growers in this area will abide by the new Reef Regulations.				
					20. Farmers should be compensated for their time spent and for capital investments needed to improve practice change beyond Canegrowers' Six Easy Steps' standards.					

Fig. 5. Ideal sort for *scientific rationalists* (from Factor 2). 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.

considered to be part of the *Great Barrier Reef*. Conversely, the prospect for a trusted water quality trading scheme (S35) was ranked significantly higher than all other discourse groups (albeit only at +1); there was reasonable salience with the potential for long term compensation contracts to improve practices above and beyond Reef Regulations (S21

ranked +2, significantly higher than others); and S20 (compensation for improvements beyond industry Six Easy Steps) was ranked at +1, but also significantly higher than other discourse groups. There was concern that the Reef Regulations would add to farming costs (S34 was ranked at +2, very significantly higher than others) and this group were the surest

that the regulations were a blunt instrument when compared with industry BMP (S36 was ranked at -1, very significantly lower than others). However, the discourse group was supportive of the overall broader role of the regulation of private property rights (S1 ranked -3). Again, S25 (soil health) was ranked the highest, however, as explained above, this statement had both a high level of consensus and salience across all discourse groups (see Section 4.2 below). Seemingly anomalously, this discourse ranked S16 (growers have a responsibility to reduce the impact of farming on water quality and the environment) relatively highly, at +3. All seven of this group's respondents placed this statement neutrally or positively; two respondents placed this statement at +4. This cannot be explained, other than perhaps by the long history of agricultural extension officers' repetition of the purpose of their work.

Overall, this discourse group is sceptical of many of the scientific concepts associated with water quality, climate change and the requirement for further change but would nevertheless be confident in accessing compensation and trading schemes to reduce DIN pollution. Whilst this might appear to be cynical, it nevertheless fits a model of economic rationalism of which *sector stalwarts* are sceptical. This economic maximisation perspective was further evidenced by one respondent stating, "growers who adopt [improved nitrogen application technologies] normally help their bottom line anyway".

For these reasons, we labelled this discourse group *economic maximisers*. *Economic maximisers* were predominantly males (7 out of 8), predominantly growers and farming contractors, the second oldest cohort (mean: 54 years old) with the second longest experience in the sector (mean: 33 years). The ideal sort for *economic maximisers* is represented in Fig. 6.

4.1.4. Discourse 4: sector defenders

This discourse group is very strongly aligned with sentiments that are optimistic about the prospects for the sector and the positive role the sugarcane sector plays in the local economy, in supporting environmental outcomes, and for the region as-a-whole. Saliently ranked statements had no strong association with any of the ToPB concepts and negatively ranked statements were dominated by *perceived behavioural*

controls and *subjective norms*, suggesting the discourse does not feel overly constrained by either the views of peers or perceived internal or external barriers to their agency. This factor was most similar to factor 3 (0.4086) and least similar to factor 2 (0.1624) (see Table 2).

This discourse group's most salient statements were associated with positive attitudes about the sector, the centrality of the sector to the region's economy, and the role of the sector in supporting the environment. S10 (well-managed agriculture has positive economic and environmental impacts) ranked highest, at +5; S13 (agriculture have traditionally been good stewards of nature) was ranked significantly higher than all other discourse groups at +3; and S30 (the whole region's economy is geared towards cane making it difficult to grow anything else) was ranked at +2. Reflecting this belief in the strength of the sugarcane sector, this discourse group was alone in thinking the industry offered a rewarding future, ranking S27 very significantly higher than all others at +4. This discourse group firmly believed the sector does not need a shake-up to maintain trust in the community, placing S6 at -5. The belief in the sector was epitomised by one respondent who stated, "growers have the best of intentions. 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".

This discourse group had a robust attitude towards their private property rights, when compared to others. S1 (growers should be freed to manage operations with less interference from government) was ranked very significantly higher than others at +1; S16 (growers have a responsibility to reduce the impact of operation on water quality) was ranked very significantly lower than others, at 0; and S5 (the balance of between the needs of agriculture and the environment are tilted in favour of the environment) was ranked very significantly higher than other discourse groups, at +2.

Similar to *economic maximisers*, this discourse group was sceptical of aspects of the science that links agricultural run-off with poor river water quality that risks reef health and the prospects of negative climate change impacts on the sector. S9 (agricultural operations have a negative impact on river water quality) was ranked at -4; S14 (the risk to the

-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.	* 27. Cane farming offers a rewarding future for the next generation of growers.	8. Poor water quality in our rivers flowing into the Great Barrier Reef Marine Park is damaging the reef environment.	** 19. Managing wetlands and landscapes for environmental outcomes can play an important role in providing employment for Indigenous People.	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.	23. Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and staying profitable.	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.	* 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.	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.
	9. Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.	12. Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	18. Landscape management (caring for country) in our region would benefit from a greater inclusion of Indigenous and Traditional Knowledge.	29. Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	22. A long-term contract could offset both the costs and risks of permanently converting a cane paddock to wetlands.	**▶▶ 35. A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	24. Higher levels of agricultural productivity can be sustained through adopting new technologies.	16. Farmers have a responsibility to reduce the impact of farming on water quality and the environment.	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 interference from government.	26. Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	* 2. The new Reef Regulations for the agricultural sector expose landholders to unnecessary financial risk in planning their operations.	7. It is likely most cane growers in this area will abide by the new Reef Regulations.	▶▶▶ 13. Australia's agricultural and grazing sectors have traditionally been good stewards of the land, nature and the environment.	**▶▶▶ 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.	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.		
		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.	* 3. The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	▶▶▶ 4. Cane growers are sufficiently kept up-to-date about the requirements of farming regulations.	▶▶▶▶ 34. The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.				
			**◀ 36. The new Reef Regulations are a blunt instrument in achieving better water quality outcomes. Industry BMP provides a more flexible route to improvements.	31. Cane growers would convert some of their low yield land to wetlands, if it was more profitable than growing cane there.	▶▶▶▶ 20. Farmers should be compensated for their time spent and for capital investments needed to improve practice change beyond CaneGrowers' Six Easy Steps' standards.					
				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.						

Fig. 6. Ideal sort for *economic maximisers* (from Factor 3). 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.

reef’s health is overstated in the media) was ranked at +3; and S12 (the risk of climate change) was ranked at -3: “it will have some effect, but not in my lifetime”, said one respondent.

This discourse group was sanguine about the impact of the Reef Regulations on their operations and confident their current practices will meet the requirements. It did not feel the regulations would add significantly to their costs (S34 ranked -4), nor would they expose landowners to risks (S2 ranked at -3), and it would not lose out internationally to less regulated producers (S17 ranked -2). Reflecting this confidence, this group felt that Reef Regulations were a blunt instrument when compared to industry BMP (S2 ranked +2, significantly higher than all other discourses). Saliency with statements associated with water quality trading and compensation and offset schemes was generally low. The trust in water quality trading systems was ranked lowly, at -3; growers requiring compensation for going beyond 6ES was ranked at -2; and both contract-related statements (S22 and S21) were ranked at -2 and -1 respectively. One respondent talked of suspicion that the current single buyer (monopsony) in offset credit purchasing was not offering fairness to farmers. The low saliency with water quality trading and offset statements was related to a general sense of self sufficiency — one respondent was critical that some sugarcane farmers were simply “lazy and just wanted a hand-out” (in the form of co-funding of practice improvement projects) and that they already had funded improvements out of their own pockets. However, this saliency with self-sufficiency is somewhat confounded by the very favourable attitude towards the role of agricultural extension programs: S23 was ranked very significantly higher than all other discourses at +4.

This discourse group has mixed views towards the role of Indigenous People and traditional knowledge in managing the environment. S18 (landscape management would benefit from traditional knowledge) was ranked neutrally, at -1 but S19 (managing wetlands and landscapes could play a role in supporting Indigenous employment) was ranked very significantly higher than others, at +2. In one instance, one respondent recalled a very positive experience of Indigenous People “caring for country” on their property for many years.

For these reasons we determined discourse group 4 to be *sector*

defenders. We have used the term ‘defenders’, as there was a pronounced and common feeling that the sugarcane sector had been under historic and selective scrutiny, whilst banana growers, in particular, were not (despite also being subject to the Reef Regulations). This group contained six members; all were men. Four of the six were growers and the remaining two were extension officers. It was the oldest cohort (average: 59), with the longest experience (average: 34). The growers in this cohort had the largest properties. The ideal sort for *sector defenders* is represented in Fig. 7.

4.2. Consensus and disagreement

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 five statements demonstrating the greatest level of consensus are reported in Table 4. The top three statements, in this instance, were within one ranking level of each other in each ideal sort. This table presents the z-score variance (level of agreement — lower values represent greater agreement) and average z-score across all four discourses (representing the general level of saliency across the four discourse groups).

The five statements that provoked the greatest level of disagreement across the discourse groups are reported in Table 5. The rewards from sugarcane farming for future generations (S27) was the most contentious statement, however, it had negative average saliency. The high z-score variance is driven by *industry defenders* ranking this statement at +4, compared to the other discourse groups, which ranked it at -3, -1, and -4 respectively. S14 (risk to the reef is overstated in the media); S9 (agricultural operations have a negative impact on water quality); and S8 (poor river water quality damages the reef environment) were also contentious. *Economic maximisers* and *industry defenders* ranked these statements with great scepticism, *sector stalwarts* neutrally, and *scientific rationalists* with the greatest trust.

-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.	34. The new Reef Regulations will add significantly to farming costs from, for example, additional record keeping, planning and soil testing.	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.*	21. A fixed-term compensation contract would be enough to persuade cane farmers to change practice to go beyond the Reef Regulations for fertiliser management.	15. Maintaining the agricultural productivity of sugar cane in the long term is the biggest challenge for the sector in Far North Queensland.	24. Higher levels of agricultural productivity can be sustained through adopting new technologies.	*▶ 36. The new Reef Regulations are a blunt instrument in achieving better water quality outcomes. Industry BMP provides a more flexible route to improvements.	*◀◀ 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.	*▶▶ 23. Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and staying profitable.	10. Agricultural land uses, when well-managed, can have a positive impact on the both the environment and the local economy.
	9. Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.	* 35. A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	20. Farmers should be compensated for their time spent and for capital investments needed to improve practice change beyond Caregrowers' Six Easy Steps' standards.	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.	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.	*▶▶ 5. The environment needs to be balanced with the needs of the agricultural sector. At the moment, it feels like environmental concerns are dominant.	*▶ 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.	
		12. Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	22. A long-term contract could offset both the costs and risks of permanently converting a cane paddock to wetlands.	8. Poor water quality in our rivers flowing into the Great Barrier Reef Marine Park is damaging the reef environment.	**◀ 16. Farmers have a responsibility to reduce the impact of farming on water quality and the environment.	*▶▶▶ 1. Farmers should be free to manage their agricultural operations as they see fit, with much less much interference from government.	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.	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.		
			26. Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	**◀ 31. Cane growers would convert some of their low yield land to wetlands, if it was more profitable than growing cane there.	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.	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.	*▶▶▶ 19. Managing wetlands and landscapes for environmental outcomes can play an important role in providing employment for Indigenous People.			
			29. Making a living in the sugar cane sector is tough, but leaving agriculture altogether is harder.	4. Cane growers are sufficiently kept up-to-date about the requirements of farming regulations.	3. The constant changes in regulation of the sugar cane sector make it hard to plan for the future.	7. It is likely most cane growers in this area will abide by the new Reef Regulations.				

Fig. 7. Ideal sort for *sector defenders* (from Factor 4). 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 4
Consensus statements.

Ref	Statement	Average Z-score	Z score variance	ToPB
10	Agricultural land uses, when well-managed, can have a positive impact on the both the environment and the local economy.	1.351	0.011	Attitude
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.	0.888	0.018	Attitude
26	Nitrogen run-off reduction technologies, like constructed treatment wetlands, are too expensive and difficult to maintain to be viable in the long-run.	-0.910	0.029	Perceived behavioural control
7	It is likely most cane growers in this area will abide by the new Reef Regulations.	0.505	0.080	Subjective norm
23	Agricultural extension programmes are of great help to the sugar cane sector in driving innovation and staying profitable.	0.841	0.112	Subjective norm

Table 5
Statements of disagreement.

Ref	Statement	Average Z-score	Z score variance	ToPB
27	Cane farming offers a rewarding future for the next generation of growers.	-0.558	1.256	Subjective norm
9	Agricultural practices and operations on cane farms have a negative impact on water quality in our rivers.	-0.667	1.247	Subjective norm
12	Climate change will likely have a severe and negative effect on the agricultural sector in my region in the future.	-0.486	1.192	Attitude
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.	-0.091	1.115	Subjective norm
8	Poor water quality in our rivers flowing into the Great Barrier Reef Marine Park is damaging the reef environment.	0.047	0.965	Attitude

5. Discussion

Our study set out to understand the range of discourses existing in the sugarcane sector in relation to innovative incentive-based policy mechanisms and towards the potential for practice and/or land use change. Further insights were obtained into attitudes towards the future of the sugarcane 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 sugarcane growers. We also set out to answer two secondary questions: (a) which discourses are most associated with positive attitudes towards innovation and a have higher likelihood of participating in schemes, such as water quality trading; and (b) which socio-demographic attributes have a greater propensity to align with the discourse groups most sympathetic to innovation. Our approach, using Q, identified four discourse groups:

(i) *sector stalwarts*; (ii) *scientific rationalists*; (iii) *economic maximisers*; and (iv) *sector defenders*.

Three of the four discourse groups demonstrated only weak salience for the group of statements that spoke most directly to the substantive research questions (S20, S21, S22, S31, and S35). Table 6 shows the z-scores for each discourse and reports the mean of the z-scores of the discourse towards this group of statements. *Economic maximisers* responded most positively (and generally positively to each). *Sector stalwarts* and *industry defenders* demonstrated the least alignment. *Scientific rationalists* ranked this group of statements relatively neutrally. S35 (a water quality trading system is a trustworthy way of improving water quality) was ranked the lowest, on average, by the four discourse groups. Two discourse groups, *sector stalwarts* and *industry defenders* ranked S35 very lowly, at -4 and -3 respectively. Both these cohorts were dominated by farmers. In addition, qualitative feedback from respondents in both cohorts cited difficulties—at least as expressed through the media—in the implementation of the Murray Darling Basin (MDB) water [quantity] trading market, in terms of entitlement, transparency, pricing, and equity, as a factor influencing their scepticism of innovative environmental markets, particularly those that restrict property rights or can be seen as reallocating resources to the environment (Downey and Clune, 2020). Without judging the efficacy of the operations of the MDB water markets, it seems unlikely that markets for water quality permit trading will be supported by the sugarcane sector until such time as the agricultural sector more broadly experiences clear financial benefit in the MDB scheme. This is not a pessimistic outlook with some studies pointing to the MDB farming sector better understanding risk and opportunities (Colloff and Pittock, 2019; Mallawaarachchi et al., 2020; Martin et al., 2023), despite reservations remaining about environmental allocation (Mallawaarachchi et al., 2020) and technical difficulties in operating a water market across multiple catchments (ACCC, 2019).

There was a reasonable level of consensus between the four discourse groups for two statements associated with the longevity of any compensation contracts (S21 and S22), 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 may assist in take-up. Optimism about the potential for wetland-based compensation payment mechanisms was confined to *scientific rationalists*, suggesting that even though they may be seen to provide acceptable payment schemes, expectations of cashflow from such schemes will not be sufficient motivation to encourage land-use conversion to wetlands as a viable option for the future.

Trust in the science and the openness of the sugarcane sector to innovative policies to improve water quality speak to the rich data on who farmers trust in providing credible information into the planning process. Farmers place greater trust in each other and are notably less trusting of “experts, particularly agricultural researchers from academic and government institutions” (Rust et al., 2022, p. 31) who are not empathetic towards their needs but are inclined to listen to messages from industry groups (Canegrowers, 2019b). Trusted farmer networks enable knowledge exchange, or spill-over, the effectiveness of which is related to the strength of social ties, not just spatial proximity (Yanbing et al., 2023). Furthermore, within these networks, ‘intermediary farmers’, who are also often key knowledge holders, play an important role in increasing the exchange of knowledge between different clusters (Skaalsveen et al., 2020). As these intermediaries can be geographically dispersed (see Fig. 2), online platforms can be important for establishing and building innovation networks outside more geographically proximate peers and promoting, or joining conversations in these spaces could be a fruitful channel in policymakers seeking to influence (Phillips et al., 2021; Skaalsveen et al., 2020).

Perhaps not unsurprisingly, given the current political context (see Section 3) and a history of mistrust between sugarcane farmers and the government, S14 (risk to the reef is overstated); S9 (agricultural

Table 6

Sentiment, by discourse, z-score variance, and mean z-score, towards statements associated with water quality trading scheme concepts.

Ref	Statement	z-Score of discourse				z-Score variance	Mean z-score
		Broad perspective optimists	Scientific rationalists	Economic maximisers	Sector defenders		
31	Cane growers would convert some of their low yield land to wetlands, if it was more profitable than growing cane there.	0.031	0.615	0.110	-0.716	0.226	0.010
21	A fixed-term compensation contract would be enough to persuade cane farmers to change practice to go beyond the Reef Regulations for fertiliser management.	-1.199	-0.247	0.747	-0.525	0.489	-0.306
22	A long-term contract could offset both the costs and risks of permanently converting a cane paddock to wetlands.	-0.616	-0.202	0.218	-1.006	0.209	-0.402
20	Farmers should be compensated for their time spent and for capital investments needed to improve practice change beyond Cane growers' 'Six Easy Steps' standards.	-0.623	-0.425	0.351	-1.009	0.246	-0.427
35	A trading system for water quality improvement certificates/credits is a trustworthy way of improving water quality.	-1.920	-0.641	0.562	-1.203	0.824	-0.801
Mean of z-scores		-0.865	-0.180	0.398	-0.892		-0.385

operations have a negative impact on water quality); and S8 (poor river water quality damages the reef environment) were contentious statements. When looked at by discourse group, *economic maximisers* and *sector defenders* were most doubtful of the science, *scientific rationalists* (unsurprisingly) were most aligned and *sector stalwarts* neutrally inclined. This implies that case for the scientific consensus is yet to be thoroughly accepted. The science-policy interface remains a highly contested area, despite the implementation of the Commonwealth Government's Caring for our Country Reef Rescue program since 2008 and significant scientific endeavour demonstrating the link between DIN run-off and threats to the GBR. However, the high level of congruence and relatively high salience of S33 (farmers would be inclined to manage nitrogen application, if they could see evidence of an impact on water quality) suggests an intention for action to reduce nitrogen emissions could be supported once the science is sufficiently demonstrated. Whilst mistrust of government and experts remains (Rust et al., 2022) (and recall one *sector stalwart* believed one monitoring station had been moved, rendering data untrustworthy) the placement of S33 presents some evidence of pragmatism on behalf of farmers and an opening for NRM and extension workers to continue to innovate in how they communicate science, particularly if *scientific rationalists* can be made more aware of the potential economic theory and potential benefit of 'cap and trade' pollution mitigation policies.

When considering the four discourse group's placements of the group of statements associated with the efficacy of water quality trading systems and the group of statements related to the scientific consensus, we are left with something of a conundrum. *Economic maximisers* are both the most positively inclined towards water quality trading concepts and the most sceptical of the scientific consensus that sets out the need for water quality trading systems. 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 GBR. However, it is accepted that the science is difficult to effectively demonstrate unambiguously, even given the improved *in situ* water quality monitoring technologies that have recently been tested in the field. Furthermore, for a regulatory market to be trusted, it must demonstrate attribution to regulated entities, which could be achieved through an expansion of autonomous *in situ* monitoring stations and further refinements in monitoring and reporting, which was already being trialled by the MIP.

Whilst Q is not designed to test the validity of the ToPB it nevertheless proved useful helping to frame, interpret, and explain the factor ideal sorts in conjunction with the demographic make-up of the factors. For example, strongly salient statements for *scientific rationalists* were dominated by *attitude* statements, whilst weakly salient statements were dominated by *perceived behavioural controls*. This suggests this discourse

group is considerably less influenced by economic and cultural constraining factors due to the nature of their occupations (mostly sciences and NRM groups), which sits somewhat aside from the tight-nit sugarcane sector community's norms and constraining factors. Conversely, *sector stalwarts*, *sector defenders*, and to an extent, *economic maximisers*, dominated by growers, showed stronger salience with *subjective norms* and, to a lesser extent by *perceived behavioural controls*, demonstrating their greater embeddedness into the region's collective sense of backing-in the sugarcane sector against political and economic forces that seek to reform it. Of these three discourse groups, *economic maximisers* were more influenced by *attitudes* pointing to a higher level of entrepreneurialism and willingness to engage with innovative schemes.

When we compare our results to prior studies—those of Kerr and Bjornlund (2018) and Buckley (2012)—we see a fair degree of alignment (see Tables 7a and 7b). There were three approximate analogues shared by all three sets of findings and each shows a single discourse that is a strong advocate for the role of agriculture as a key economic sector in rural areas. These discourses are: generally sceptical of the science and any links between farm emissions and poor water quality; are sceptical of subsidy and transfers; are driven, instead, by a moral code towards what they think is right thing to do, rather than any demand for compensation; and is moderately propertarian (Widerquist and McCall, 2020). Each study also reveals a scientific- or administrative-rationalist type discourse group, which is environmentally focussed and positive towards the justification and implementation of activities to improve water quality. In all studies, this discourse group 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. Kerr and Bjornlund (2018) and Buckley (2012) also reveal a more progressive cohort, which does include *some* farmers who are open to innovation but would still benefit from a clearer demonstration of the science (Table 8). We could not see a clear analogue in our findings. Finally, our study also reveals a 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, regardless of their scepticism of the scientific case for water quality improvements. This is not reflected in the findings of Rolfe et al. (2018) and Brown et al. (2020) who emphasise the importance of non-financial and psycho-social factors (autonomy, longevity, social norms) in driving behaviour change.

Our study faced some limitations. Firstly, all sugarcane growers in the Tully and Ingham region rely on rain for cropping. Farm operations, from the timing of planting, fertiliser application, and harvesting are strongly influenced by weather. This contrasts with the operations of sugarcane growers who have access to irrigation schemes and thus can regulate watering and thereby have greater control over farm

Table 7a
Socio-demographic make-up of each factor.

Discourse	Total	Gender		Mean age	Mean years' experience	Median area cane	Involvement in schemes (of identified farmers only)		
		Female	Male				Gov.	Cane-growers	None
Sector stalwarts	11	0	11	46	29	140	5	2	1
Scientific rationalists	12	6	6	43	20	183	4	1	0
Economic maximisers	8	1	7	54	33	188	3	4	1
Sector defenders	6	0	6	59	34	280	1	1	1
Total	37	7	29	48	25	320	13	7	3

Table 7b
Occupation by factor.

Factor	Occupation					
	Farmer	Contractor	Agricultural extension	Science	NRM	Other
F1: Sector stalwarts	8	2	1	0	0	2
F2: Scientific rationalists	3	0	3	5	2	1
F3: Economic maximizers	7	1	1	0	0	0
F4: Sector defenders	4	0	2	1	0	0
Total	22	3	7	6	2	3

Table 8
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).

Kerr and Bjornlund (2018)	Buckley (2012)	Our findings	Comparisons
Incentive orienteers			No clear analogue in our results.
Rural advocates	Constrained productionists	Sector defenders & sector stalwarts	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	Economic maximisers	Disposed to innovation and optimism; keen to see clearer demonstration of science.
	Regulation unaffected	Sector defenders	Sanguine about the impacts of regulation. Confident they are already operating at standard.

operations, who nevertheless face higher input costs. It would be useful to test whether this greater control over farm operations and increased costs would have a positive effect on their sentiment towards market-based instruments to improve water quality. Secondly, though Q demands strategic sampling, it remains difficult to reach a truly diverse range of sugarcane farmers. Despite efforts, all our sample was, to some extent, engaged by agricultural extension officers in practice improvement from Cane growers, the local sugar mill, or NRM groups. Our sampling likely lacked perspectives from growers not engaged by programs. It is unknown whether sampling such growers would challenge, or extend, the factors uncovered in our study. The modest sample size in Q also make for opportunities to combine it with social network analysis

(for example, see Skaalsveen et al., 2020), to determine if respondent's network intensity can have bearing on discourse membership. Finally, though sampling banana farmers was beyond the funded 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 sugarcane growers during our sampling that their sector seemed to be held continually under the spotlight in terms of concerns around improving GBR 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 GBR water quality monitoring and improvement plans. Our sampling of sugarcane growers, as directed by the research funding, only contributed to their sense of injustice, which may have influenced perceptions of the task. Notwithstanding, sampling the attitudes of banana farmers would be worthwhile.

Our study demonstrated how understanding sugarcane sector normative beliefs, attitudes, behavioural constraints, through identifying and analysing key discourses contributes to generating actionable recommendations. Ultimately, success in improving agricultural practices and perhaps taking the highest risk paddocks out of production will be dependent on building constructive engagement between policy makers and the sugarcane sector and win-win type arrangements, such as compensation schemes, which is epitomised in the high level of congruence (0.011) and a high level of salience (2nd out 36) given to S10 (agricultural land uses, when well-managed, can have a positive impact on the both the environment and the local economy). The lack of progress made by the global community towards reducing emissions in line with Paris Agreement ambitions is likely to see an intensification of climate risks to the GBR. Controlling the impacts of co-stressors, particularly those within the purview of purely Australian domestic and Queensland state policy, such as reducing DIN emissions from agricultural operations and improving the water quality in catchments flowing into the GBR lagoon, will become an increasingly important task for policy makers. Furthermore, decreasing water-borne pollution will also be instrumental to Australia fulfilling its obligations in the Kunming-Montreal Global Biodiversity Framework (Convention on Biological Diversity, 2022), particularly Target 7 — reducing excess nutrients lost to the environment by at least half.

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CRedit authorship contribution statement

Andrew Buckwell: Conceptualization, Methodology, Formal analysis, Resources, Data curation, Writing – original draft, Visualization. **Maria Ribbeck:** Investigation, Writing – review & editing, Project administration, Resources. **Joshua Dyke:** Investigation, Writing – review & editing. **Jim Smart:** Conceptualization, Methodology, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Gregor Edeson:** Methodology, Project administration, Funding acquisition.

Declaration of competing interest

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Data availability

Data will be made available on request.

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