



**MOSAIC**  
insights

**Great Barrier Reef Foundation**

**Reef Sugarcane  
Landholder  
Characterisation Report  
Final**

**Social monitoring and evaluation program**

21 December 2022

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## Acknowledgement of the First Nations People of Australia

Mosaic Insights, as part of the Alluvium Group of companies, recognises and acknowledges the unique relationship and deep connection to Country shared by First Nations People, as the Traditional Owners and First Peoples of Australia. We are committed to supporting close involvement and participation of First Nations People in aquatic research and management.


First Nation People attach enormous cultural and spiritual significance to landscapes. In the First Nation Peoples' world view, people and Country (including lands, waterways and seas) are interdependent entities that are intrinsically linked in the landscape. This means that there is no separation of nature and culture. The health and wellbeing of First Nations Peoples is directly influenced by both the health of the environment and the degree to which First Nation People can be actively involved in caring for it.

As First People of Australia, Traditional Owners have inherent rights that were never traded or given away. These inherent rights are recognised in a wide range of International, Federal, State and Territory Government instruments that afford First Nation People ownership and custodial interests in Country and recognises their unique responsibility to care for their communities, cultural landscapes, biodiversity and places of particular cultural significance. Ongoing access to Country and its resources is essential so First Nation People can continue cultural practices, maintain links with the land and care for and be intricately involved in repairing Country. First Nation individuals and communities can retain and obtain valuable knowledge and skills through being proactively involved in environmental management and conservation opportunities.

Australian society can benefit from First Nation People's knowledge, relationships and cultural and environmental practices and protocols that are alive and vibrant in these communities. This engagement will provide society with a foundation to establish meaningful and sustainable relationships and sound working partnerships.



*The cover artwork is by Biripi woman Vicki Golding and was commissioned by the Alluvium Group as part of the development of our organisation's Reconciliation Action Plan. It tells the story of the water catchment flowing to the coast, with both men and women meeting together to discuss protecting our environment. We chose the Eagle as our totem animal, flying high, watching over the land, powerful and strong.*



**“I think the big thing is that there's no recipe,  
there's no fixed rule. You know, we're individuals.  
We all don't want to be treated the same”**

(local expert 9)

# Executive Summary

As part of the Water Quality Component of the Reef Trust Partnership, a total of \$138.1 million has been committed across ten regional water quality programs that will directly reduce nitrogen, sediment and pesticide loads from priority Reef catchments. The regional water quality programs deliver projects that focus on proven, voluntary on-ground measures for improving water quality, including improved land management practices with sugarcane growers. Delivering improved land management practices within the sugarcane industry requires effective engagement with landholders.

Not all landholders are the same and within the cane growing sector different farmer community profiles exist. There are many individual level factors such as farm size, financial capacity, off-farm income, innovation levels, succession planning, involvement in agri-environmental schemes, trust for government, diversification and the landholder's values towards the environment, profitability and lifestyle that play a role in determining how and why landholders engage in practice change.

Natural Capital Economics (NCE) has previously worked with the Great Barrier Reef Foundation (GRBF) to develop a landholder typology based on the individual level factors that influence landholder decisions, in particular where these decisions relate to land use transitions (e.g., leaving, growing (buying), diversifying, intensifying, or improving practice) ([NCE, 2020a](#)). This NCE work used a literature review and expert interviews to identify five broad, non-mutually exclusive landholder groups;

- Traditionalist,
- Lifestyle/Hobby Farmer,
- Conservationist,
- Enterprise Farmer, and
- Experimenter/Diversifier

GBRF commissioned Mosaic Insights to conduct social science research to build a deeper understanding of the social context of landholders and how different social factors might enable or inhibit practice change. This project sought to build on previous work in this space and further our understanding through using a mixed method approach with quantitative survey data and qualitative interview data.

For the quantitative approach, we used the 2021 Future of Farming Survey<sup>1</sup> data which collected data on individual landholder characteristics such as farm size, off-farm income, succession planning and personal values. We conducted K-means clustering and principal component analysis with the Future of Farming Survey data which allowed us to describe five distinct groups/profiles within the data and these groups broadly aligned with the five-segment landholder typology as identified through the previous work by NCE.

For the qualitative data approach, we conducted interviews with ten local experts. These experts were chosen to provide a broad range of perspectives that included representation across the different regions of the Great Barrier Reef (GBR) as well as across the delivery network (e.g., regional program coordinators, extension officers and program managers, delivery provider staff). All interviews were recorded and transcribed using the Microsoft Teams auto-transcription function. A coding frame was developed that was structured on the ecological systems theory

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<sup>1</sup> See appendix E in NCE (2020a)

(Bronfenbrenner, 1992), where themes and codes were developed to represent the different system levels. The system levels included in coding frame are as follows:

- the individual level (individual landholder demographic factors or individual farm characteristics),
- the microsystem level (immediate environment such as the landholder's relationships with other people),
- the exosystem level (social structures that have influence over micro-systems, for example, the landholder's engagement with the farming sector); and,
- the macrosystem level (socio-cultural elements, for example, how broader environmental changes and policy landscapes affect the landholder).

The results of the qualitative analysis revealed the following factors that shape practice change across the different system levels:

**Individual** level factors shaping practice change:

- farm size and location
- innovation levels and digital literacy
- financial capacity
- off-farm income
- succession planning
- stress and mental health
- involved in agri-environmental schemes
- trust
- diversification
- profit/expansion values
- environmental values
- lifestyle values
- age and life stage
- education, knowledge and perceptions of practice change

**Microsystem** level factors shaping practice change:

- Trust and respect between extension officers and landholders
- Role of spouse and family members in farm management
- Mindset and culture of the growing community
- Social identity and connection with growing community

**Exosystem** level factors shaping practice change:

- Conflict and unity across the delivery network
- The role of mills, productivity services and resellers
- Media discourse and industry narrative
- Workforce demand and supply

**Macrosystem** level factors shaping practice change:

- Climate change and natural disasters
- Regulatory environment
- Market conditions
- Technology and connectivity

Based on analysis of the interview data we developed 'practice change approaches' to help optimise engagement effectiveness of the regional water quality programs and projects. We identified four approaches that can be used individually or in combination when engaging with landholders:

- Approach 1: Telling the whole story
- Approach 2: Profitability and productivity
- Approach 3: The good grower
- Approach 4: Hope for the future

We provide guidance on how these approaches might be applied across the different landholder profiles.

This work has provided further quantitative evidence supporting the existence of distinct profiles within the sugarcane farming communities. However, interviews reveal that not one size fits all when engaging with landholders, regardless of which profile that landholder might most strongly identify with. Using a systems-thinking approach, we analysed the qualitative data to identify the different factors that shape practice change across different system levels. This builds a valuable understanding on the social system of practice change in the cane growing sector. Informed by this social context, we developed engagement approaches to support effective engagement with landholders in practice change.



# 1 Introduction

Recognised for its Outstanding Universal Value, the Great Barrier Reef World Heritage Area (the Reef) is both amazing and extremely vulnerable. More than the jobs it supports and the value it adds to the economy each year (in 2017 the Great Barrier Reef was valued at \$56 billion) (Deloitte, 2017), the Reef is recognised as one of Australia’s most loved social and iconic assets. Yet, the current outlook for the Reef is considered to be very poor (GBRMPA, 2019).

While climate remains its greatest threat, the quality of water entering the Reef from adjacent catchments remains one of the major management issues for protecting the Reef (GBRMPA, 2019). With an investment of \$201 million over six years, the water quality program delivered by the Great Barrier Reef Foundation (GBRF) through the Reef Trust Partnership (RTP) aims to address the water quality impacts affecting the Reef. Ten regional water quality programs are underway to directly reduce dissolved inorganic nitrogen (DIN), sediment and pesticide loads from priority Reef catchments. The programs are focusing on proven, on-ground measures for improving water quality including catchment restoration and improved land management practices. These 10 programs are expected to result in 456 fewer tonnes of dissolved inorganic nitrogen (DIN), 250 fewer kilograms of pesticides and 462 fewer kilotonnes of sediment entering the Reef every year from 2024. Five of these programs are working with farmers in the sugarcane industry to change farm management practices to be of lesser risk to nutrients and pesticide runoff.

There is recognition<sup>2</sup> that the suite of projects and activities being delivered on ground have not capitalised on the growing body of evidence (Rundle-Thiele et al., 2021, Coggan et al., 2021) supporting the use of behavioural insights to deliver accelerated outcomes for both the landholders involved in the project as well as the Reef. Water quality regional programs need the ability to adapt under a continuous improvement framework and to adjust the engagement strategies to continue to be best aligned with the overarching policies and objectives and to ensure enduring practice change.

This project increases our understanding of the social factors, both individual and broader community and system level social factors, that can influence the outcomes of the GBRF water quality program, and to use those insights to deliver an improved program that can accelerate and sustain outcomes that will improve water quality.

Natural Capital Economics (NCE) has previously worked with GBRF to develop a landholder typology based on the financial and non-financial factors that influence landholder decisions about farm management practices ([NCE, 2020a](#)). This work resulted in the identification of five broad, non-mutually exclusive landholder groups:

1. Traditionalist,
2. Lifestyle/Hobby Farmer,
3. Conservationist,
4. Enterprise Farmer, and
5. Experimenter/Diversifier

[NCE \(2020a\)](#) identified and mapped how different financial and non-financial factors (such as age/lifestage, financial capacity, values, social identity and networks, farm size) influence landholder decisions in particular where decisions relate to land use transitions (e.g., leaving, growing (buying), diversifying, intensifying, or improving practice). This work was informed by an extensive review of the literature as well as interviews with key academic and government stakeholders relevant to the Reef catchments.

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<sup>2</sup> In March 2021 the Reef Trust Partnership (RTP) Water Quality Program established a team of 13 experts under the Technical Advisory Group (TAG) arrangement to conduct a gap analysis to identify opportunities to improve the program’s M&E framework.

In addition to this work, it is recognised that there is a wealth of knowledge, both documented (Rundle-Thiele et al., 2021, Coggan et al., 2021) and with extension officers, on the barriers and motivations of landholders engaged in water quality related projects. This report builds on this existing knowledge to identify what works, for whom, and why in the context of engaging sugarcane growers in practice change. This report is focused on drawing this information together so that it can be used to drive more effective project delivery and embed adoption of land management practices that will achieve lasting positive change for the Reef.

## 2 Quantitative data approach

This section summarises the results of a rapid and focused desktop literature review and audit of secondary datasets. The purpose of this desktop review was to identify a feasible and appropriate method (and data sources) for validating the typology developed by NCE (2020a).

### 2.0 Background

As mentioned in section 1.1, NCE previously worked with GBRF to develop a landholder typology based on the factors that influence landholder practice change decisions (NCE, 2020a). The typology draws on an extensive literature search of research conducted with agricultural landholders in Australia.<sup>3</sup> The typology was further refined and validated through semi-structured interviews with 16 content experts across the fields of social science, behavioural science, agriculture, economics, and socio-cultural research.

This work resulted in the identification of five broad, non-mutually exclusive landholder groups:

- Traditionalist,
- Lifestyle/Hobby Farmer,
- Conservationist,
- Enterprise Farmer, and
- Experimenter/Diversifier

Based on the findings of the literature review and expert interviews, NCE (2020a) identified the following factors as being the most likely to shape landholder engagement in agri-environmental programs, practice change adoption, and to characterise different landholder types:

- farm size,
- innovation levels,
- financial capacity,
- off-farm income,
- succession planning,
- involved in agri-environmental schemes,
- trust for government,
- diversification,
- profit/expansion values,
- environmental values, and
- lifestyle values.

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<sup>3</sup> "The research focused on studies from the last 10-15 years conducted in catchments adjacent to the GBR, primarily in the sugarcane industry, but extending to some other geographies and primary production industries of grazing and grain, where relevant." (NCE, 2020a).

Subsequently, the 'Future of Farming' survey was developed (NCE, 2020b). Hosted via an online platform, the survey was designed to collect data from Queensland canefarmers. It includes 33 questions on Queensland canefarmer management practices, planning and decision making and attitudes to risk. While the primary focus of the 'Future of Farming' survey was to look at economic factors to farm management decision making, there were also a number of indicators and data collected on social factors. The survey provides valuable primary research data on the indicators identified for determining a landholder typology, however it did not include any questions that relate to the indicator of 'trust for government'. Furthermore, another drawback of these data is the small sample size. In total, the survey was only able to capture the responses of 73 Queensland canefarmers. The survey respondents' ages ranged from 35 to 93 years, with an average age of 64 years. The survey included respondents from the Wet Tropics (n=32), Burdekin (n=14), Mackay Whitsundays (n=21) and Burnett Mary (n=6) regions, with most respondents from the Wet Tropics region (43%), and the least number of survey respondents from the Burnett Mary region (8%). The distribution of survey respondents was generally representative of the broader cane farming industry, whereby there are more cane farmers located in the North compared to the Southern Reef regions.

As part of this landholder characterisation project a desktop review was conducted to assess the availability and suitability of secondary datasets that could potentially provide data towards the factors identified by NCE (2020a). Some of the secondary datasets identified were:

- *Farm financial performance, sugarcane businesses, 2020-21 to 2021-22* (ABARES, 2021) – Survey of sugarcane businesses with results broken down by growing region. As well as farm financial performance, it included questions around physical characteristics of farms (e.g., farm size, yield, etc.) and farm management (e.g., recent investments, future intentions). Applicable to many of the indicators, although, it is not very spatially granular, and the data are not provided at the individual response level.
- *Spatial data on land use* (Queensland Government, 2020a) and *property boundaries* (Queensland Government, 2020b) – Land use mapping of sugarcane areas (both irrigated and non-irrigated) was used in conjunction with property boundaries to extract farm-level farm size data. This is relevant only for the 'farm size' indicator.
- *Queensland Rural Debt Survey* (QRIDA, 2019) – Provides data on levels of farm debt at a regional level. This is specifically applicable to the 'financial capacity' indicator. The data is not very spatially granular (data is provided for only two regions within Queensland).

Finally, a brief literature review was conducted to gain a better understanding of the similarities and differences of the key indicators used to determine landholder typology in the broader Australian literature versus those used in this report (noting that quantitative typology research specific to the cane industry was not found). From the literature (Emtage & Herbohn, 2012; Graymore et al, 2015; Kuehne, 2009; Morgan et al, 2015; Schwarz et al, 2009), it was discovered that indicators and measures used to determine landholder typology varied largely, with many studies' indicators overlapping with that of this research. Of the literature reviewed, farm size, innovation levels, financial capacity, succession planning, trust for government, profit/expansion values, environmental values and lifestyle values were commonly used indicators. Whether a landholder was involved in agri-environmental schemes was also an indicator found in the literature (Morgan et al, 2015). Despite being less common than other indicators it was also noted as important by NCE (2020a) and therefore also warrants inclusion in this analysis... While NCE (2020a) found that off farm income and diversification are important factors that influence landholder decisions, they were not observed in the quantitative typology literature review. Landholder self-reliance for decision making, need for additional information for decision making, attitudes about labour (Graymore et al, 2015), and attachment to place (Morgan et al, 2015) are examples of indicators that were found in the literature but are not included in the analysis due to a lack of suitable available data. It should also be noted that these papers were not specific to the sugarcane industry and the indicators in question were not identified as important to shaping practice change decisions by NCE (2020a). It is important to note that indicators implemented are likely to differ between landholder characterisation research due to the variations in research goals, and different industries or locations of focus<sup>4</sup>. As the research goal in

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<sup>4</sup> For example, Schwarz et al (2009) developed a farmer typology to assist in a practice change program to encourage farmers to capture the benefits and new enterprise opportunities arising from conversion to the more efficient piped water supply delivered by the Wimmera Mallee pipeline in

this case is to build a deeper understanding of how different factors might enable or prohibit practice change, indicators have been selected to best achieve this.

## 2.1 Review of data methodologies

A brief review of the literature was conducted to gain an understanding of existing and appropriate data collection and analytic methods for characterising sugarcane landholders into their appropriate landholder types.

From a review of the existing literature, it became clear that K-means cluster analysis was the technique implemented in the majority of landholder typology research (Emtage & Herbohn, 2012; Schwarz et al, 2009; Graymore et al, 2015; Kuehne, 2009). K-means cluster analysis is an analytical technique that discovers mutually exclusive subgroups by splitting data into a number of groups to maximise the variation between clusters and minimise the variation within a cluster (Everitt et al. 2011). Graymore et al (2015) state that the advantage of this approach is that emerging styles are grounded in survey data, and the technique shows how patterns in data fall into natural groupings. Employing the K-means clustering technique for grouping farmers means differences in 'patterns of beliefs and attitudes about farming' (Thomson 2002 p. 281) can be measured.

From the literature reviewed, Nicholson (2022) represented the only quantitative research to not implement a K-means cluster analysis technique in the creation of a farming/landholder typology. Nicholson used Myer Briggs Type Indicators (MBTI), which were further refined to describe four distinct 'temperament' types (based on Keirsey (1987)). The Myer Briggs test typically contains 93 questions, of which the respondent receives a score across four different preference scales (extroversion-introversion, sensing-intuition, thinking-feeling, judging-perceiving). A cut-off exists at the centre of the preference scale such that a score on one side is classified as one type, and a score on the other side as the opposite type. With four different dimensions in Myers-Briggs' MBTI there are thus 16 combinations of possible personality types. Keirsey (1987) grouped the MBTI 16 personality types into four different temperaments that focus more on behaviour and actions than on "inner-life", including the artisan (SP), the guardian (SJ), the rationals (NT), and the idealists (NF), of which represented the four farmer types in Nicholson's research.

Other research that has sought to characterise landholder types have taken a more qualitative approach, noting the aim of this analysis is to provide a *quantitative* assessment of landholder types. Bohnet et al (2011) implemented a series of 'semi-structured' interviews in determining a typology for graziers' land management strategies and its importance for sustainability in the Bowen-Broken catchment. Interview questions were open-ended, allowing for new insights to emerge during the study. Bohnet et al (2011) deemed this as important to gain a better understanding of the social and economic situation of graziers and how that relates to their management approach. Bohnet et al (2011) formulated a typology by coding responses to identify patterns and themes in the interview data. Kuehne (2009) included open-ended qualitative questions as a part of their survey and applied a 'cut and sort' technique to develop farmer types constructed by classifying the values and attitudes that they hold with regard to family, land, water, community and lifestyle as well as profit, and how this might explain or even predict their management behaviour. Moon & Cocklin (2011) sought to understand landholders' motivations and barriers to conserve biodiversity and used interviews to administer a qualitative open-ended survey. Respondents were asked about their main considerations in terms of participation; motivations to participate; selection of conservation areas and extent of land conserved; the percentage of the property committed to formal conservation; and their barriers to using more land for formal conservation. Moon & Cocklin (2011) formulated typology by coding responses to identify patterns and themes in the interview data. Finally, Van Grieken et al (2009) developed a typology via qualitative interviews with the widest possible range of farmers and land managers to help predict how different types of farmers, or farming agents, will respond to different policy interventions.

As described above there are a number of analytical approaches for characterising sugarcane landholders into their appropriate landholder types. For the purposes of this research, which sought to apply a quantitative approach using

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Victoria. Consequently, 'water management issues' (survey questions measured knowledge, attitude, concerns and aspirations with respect to the pipeline) was an indicator for Schwarz et al's (2009) research.

existing data, it was deemed that the k-means cluster analysis was most appropriate given that this approach is widely accepted in the literature as an appropriate method in landholder typology research.

## 2.2 Analytical Approach

This section details and rationalises the approach and data that we implemented for characterising Reef sugarcane landholders into their appropriate landholder types for this study. It is then detailed how the Principal Component Analysis (PCA) and K-means clustering data analysis techniques are utilised to produce landholder types for reef sugarcane landholders. Finally, we present how the types are distributed across the various farming regions within Queensland.

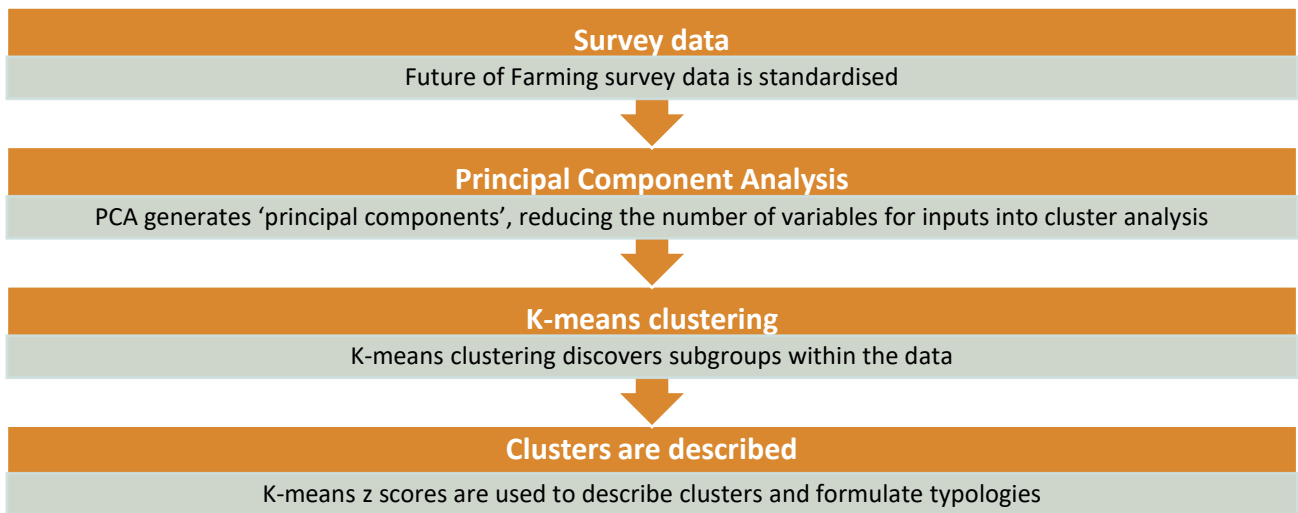
It was decided that, despite its small sample size, the data provided by the Future of Farming survey would represent the sole source of data used to characterise Reef sugarcane landholders into their appropriate landholder types in this report. The decision was made as the Future of Farming survey data is the data that best represents the identified indicators (from earlier profiling work by NCE) in determining landholder types, while also providing data at the individual response level. Other secondary data sources such as ABARE's *Farm financial performance, sugarcane businesses, 2020-21 to 2021-22* (ABARES, 2021), which were discussed in Section 2.0 were not considered appropriate for addressing our research aim due to a lack of spatial granularity and data only being presented at an aggregate level for different farming regions (which would not enable us to capture the distribution of landholder types within different farming regions). Data lacking in spatial granularity would create difficulty in understanding how the landholder types are distributed among the various farming regions of Queensland and understanding the representativeness of the data.

PCA in conjunction with the K-means cluster data analysis technique were chosen to analyse the data and characterise Reef sugarcane landholders into their appropriate landholder types. PCA is used for reducing the dimensionality of datasets, increasing interpretability but at the same time minimizing information loss. It does so by identifying the optimal number of 'principal components' within the dataset that capture most of the information within the data<sup>5</sup>. This provides a shorter list of variables (while maintaining the majority of the information in the dataset) which can then be used in the K-means clustering analysis.

With its ability to discover mutually exclusive subgroups within a dataset, it became quickly evident why K-means clustering represents the most prevalent data analysis technique within the existing landholder typology research. Furthermore, it is also generally accepted that there are no rules regarding a minimum sample size for K-means clustering (Mooi & Sarstedt, 2011). Prior to conducting either PCA or K-means clustering, each variable within the dataset was standardised (as Z scores) to ensure that each variable had an equal influence in subsequent component analysis. Figure 1 details the approach taken to characterise Reef sugarcane landholders into their appropriate landholder types.

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<sup>5</sup> Principal components are vectors that are orthogonal to each other. This means they form a 90-degree angle. Mathematically, orthogonal vectors are independent, meaning the variance explained by the second principal component does not overlap with the variance of the first, so they represent information as efficiently as possible. The first principal component will capture most of the variance; the second principal component will capture the second-largest part of the variance that has been left unexplained by the first one, etc.



**Figure 1. Approach**

**Table 1. Indicators measuring individual landholder factors in the Future of Farming Survey**

<b>Individual Factor</b>	<b>Indicator</b>	<b>Future of Farming survey question</b>
<b>Financial capacity</b>	Farm debt	My existing levels of farm debt make it more difficult to invest in new initiatives that would improve the long-term performance of my farm, including diversifying into new cashflow generating opportunities.
	Off farm income	My farm relies heavily on off-farm income to get through commodity price downturns and climate cycles.
<b>Farm size</b>	Farm size (ha)	What is the total area of your farm/s in hectares?
<b>Innovation levels</b>	Attitudes towards technology	I like taking risks on new technologies and market opportunities.
<b>Farm planning</b>	Expansion	How likely are you to expand your farming business in the near future? (i.e., in the next 5 years).
	Diversification	I am likely to diversify my farming operation to take advantage of environmental markets (e.g., payments for carbon sequestration) in the future.
	Intensification	How likely are you to intensify your farming business in the near future? (i.e., in the next 5 years).
	Succession planning	Do you have a succession plan? (i.e., a plan to pass the farm onto the next generation, or a plan to sell the property)
<b>Identity</b>	Cane farmer identity	Being a cane farmer is an important part of my identity.
<b>Values</b>	Economic values	My on-farm decision-making is primarily financially motivated.
	Environmental values	My on-farm decision-making is primarily motivated by a desire to be a land steward.
	Lifestyle values	My on-farm decision-making is primarily motivated by opportunities to benefit from the farming lifestyle.
<b>Involvement in agri-environmental schemes</b>	Smartcane BMP adoption	Have you adopted Smartcane Best Management Practices (BMP) on your farm?
<b>Trust</b>	Trust for government	Not asked
	Trust in science	Not asked
	Trust in delivery providers/extension officers	Not asked



## 2.3 Results

### Principal component analysis

Using Stata Corp (2017) (a general-purpose statistical software package), PCA was conducted to generate a shorter list of variables (principal components) for performing K-means clustering analysis. Eigenvalues are used as measures to indicate how good a component is as a summary of the variables. The Kaiser-Guttman rule states that components based on eigenvalues greater than 1 should be retained (Jackson, 1993). The PCA found that the first five principal components contained eigenvalues of greater than 1. In other words, the PCA informs us that five principal components will provide the maximum amount of information within the new variables while minimising the number of new variables needed. Subsequently, PCA identifies that five principal components can most optimally represent the information contained within all of the variables. Table 2 below details eigenvalues and cumulative for the PCA.

Table 2. PCA eigenvalues

Component	Eigenvalue	Difference	Proportion	Cumulative
Component 1	3.368	1.445	0.259	0.259
Component 2	1.922	0.423	0.147	0.407
Component 3	1.499	0.256	0.115	0.522
Component 4	1.242	0.068	0.095	0.617
Component 5	1.173	0.351	0.090	0.708
Component 6	0.822	0.092	0.063	0.771
Component 7	0.729	0.162	0.056	0.827
Component 8	0.567	0.022	0.043	0.871
Component 9	0.544	0.053	0.041	0.913
Component 10	0.491	0.125	0.037	0.950
Component 11	0.365	0.092	0.028	0.979
Component 12	0.273	0.273	0.021	1.000
Component 13	0.000	0.000	0.000	1.000

### K-means clustering

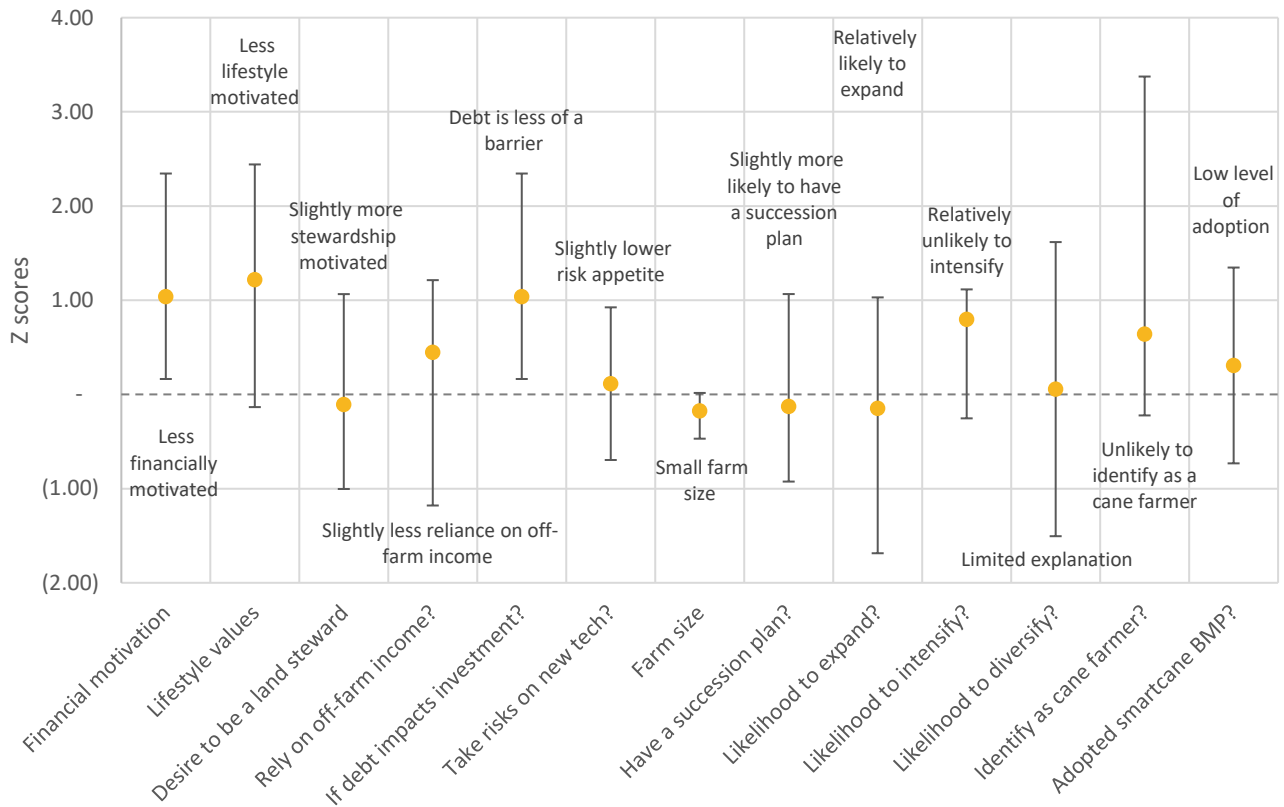
Using R (a software program for statistical analysis), K-means clustering was then conducted to discover mutually exclusive subgroups by splitting the data into five clusters (quantity identified by PCA) by maximising the variation between clusters and minimising the variation within a cluster. K-means clustering was performed in R because of R's ability to perform a specific variant of K-mean clustering called 'K-means++'. The K-means++ algorithm is able to choose the initial values (or "seeds") for the K-means clustering algorithm and ensures a smarter initialization of centroids and cluster quality (Arthur & Vassilvitskii, 2006).

In attempting to determine the optimal quantity of clusters the 'elbow method' was employed. The Elbow method is a visual method for determining cluster quantity, where the cluster analysis is run with many different K values (in this analysis, the elbow method was performed with K values of 1 – 10). For each value of K, the WSS (Within Sum of Squares) is calculated. WSS is the sum of squared distance between each point and the centroid in a cluster. The WSS value is largest when K = 1. As the number of clusters increases, the WSS value will start to decrease. Typically, when the WSS is plotted with the K value, the plot looks like an 'elbow' (i.e., the graph has a relatively large change in slope at a particular K value, thus creating an elbow shape). From this point, the graph's slope becomes relatively flat. The K value corresponding to this point is the optimal K value (the optimal number of clusters) (Syakur et al., 2018).

The results of the elbow method in this case were unclear. When the WSS was plotted with the K value, there was no distinct kink in the plot that looked like an 'elbow' (i.e., the graph did not rapidly change at any point). Consequently, as

no clear optimal number of clusters was determined by the elbow method, a K value of 5 was used for the K-means clustering analysis to determine whether 5 clusters in the data would have commonalities with the clusters previously determined by NCE (2020a).

The interpretation of clusters is determined by the associated values for each cluster. Standardised minimum, mean and maximum values for each variable were generated for each cluster, and are reported below for each of the five clusters generated. Each figure below contains interpretation around the standardised minimum, mean and maximum values for each variable for each cluster.



**Figure 2. Cluster 1 z-scores**

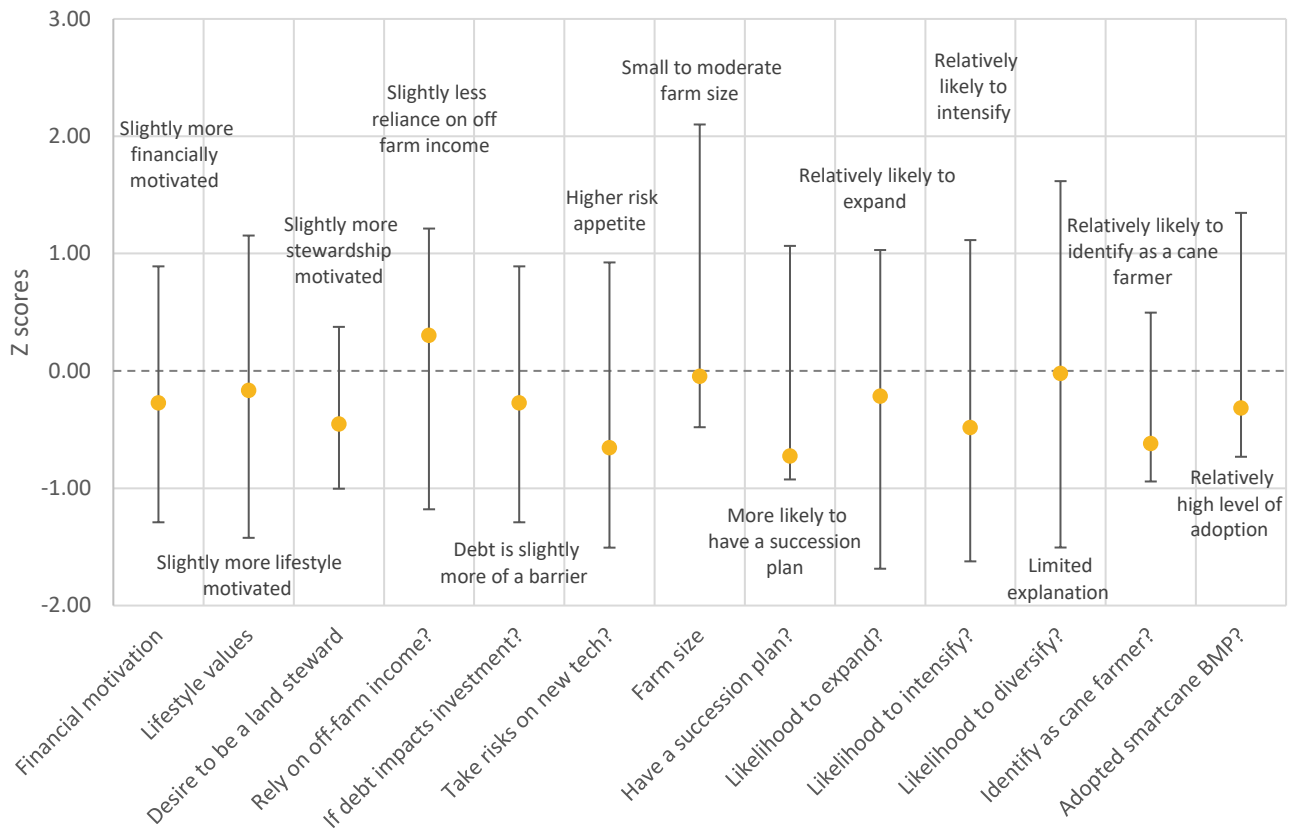


Figure 3. Cluster 2 z-scores

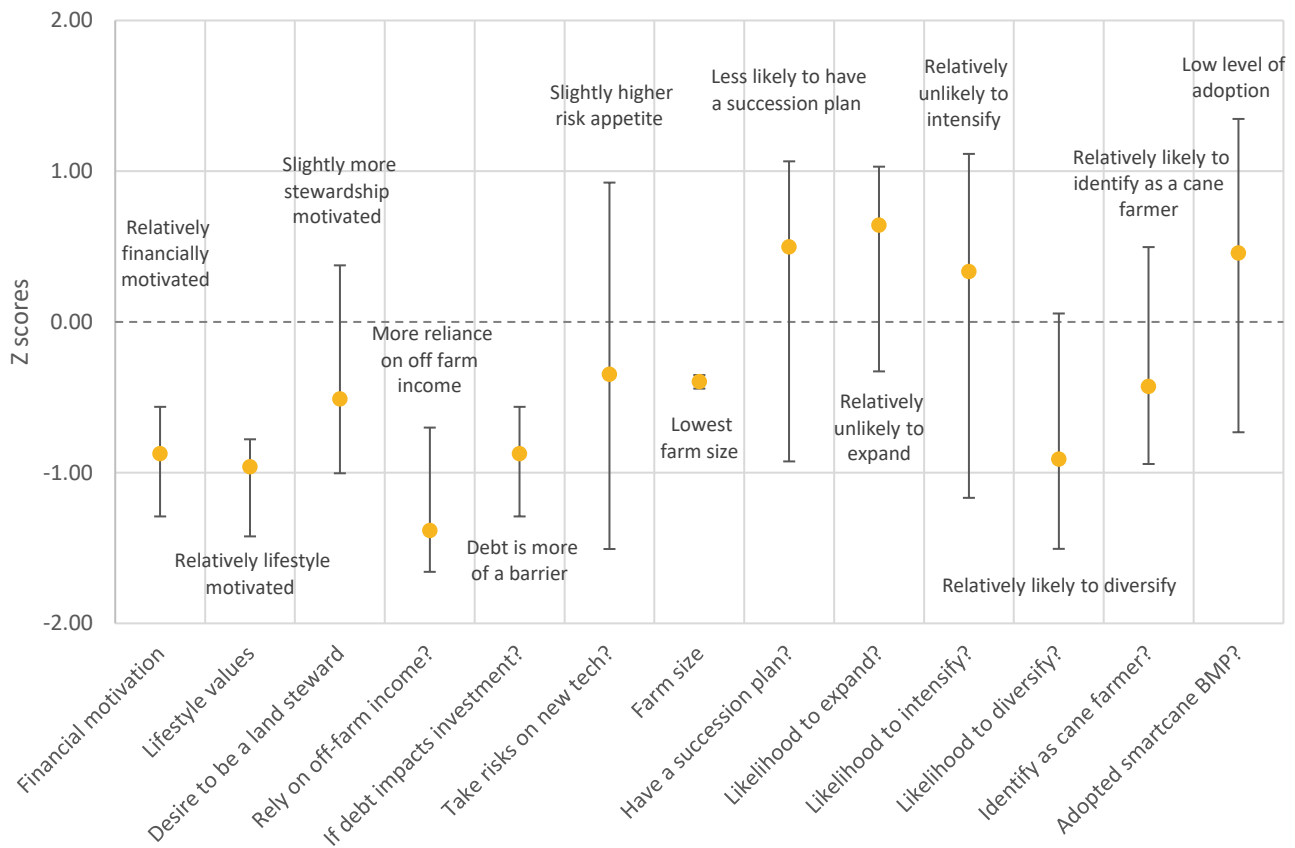


Figure 4. Cluster 3 z-scores

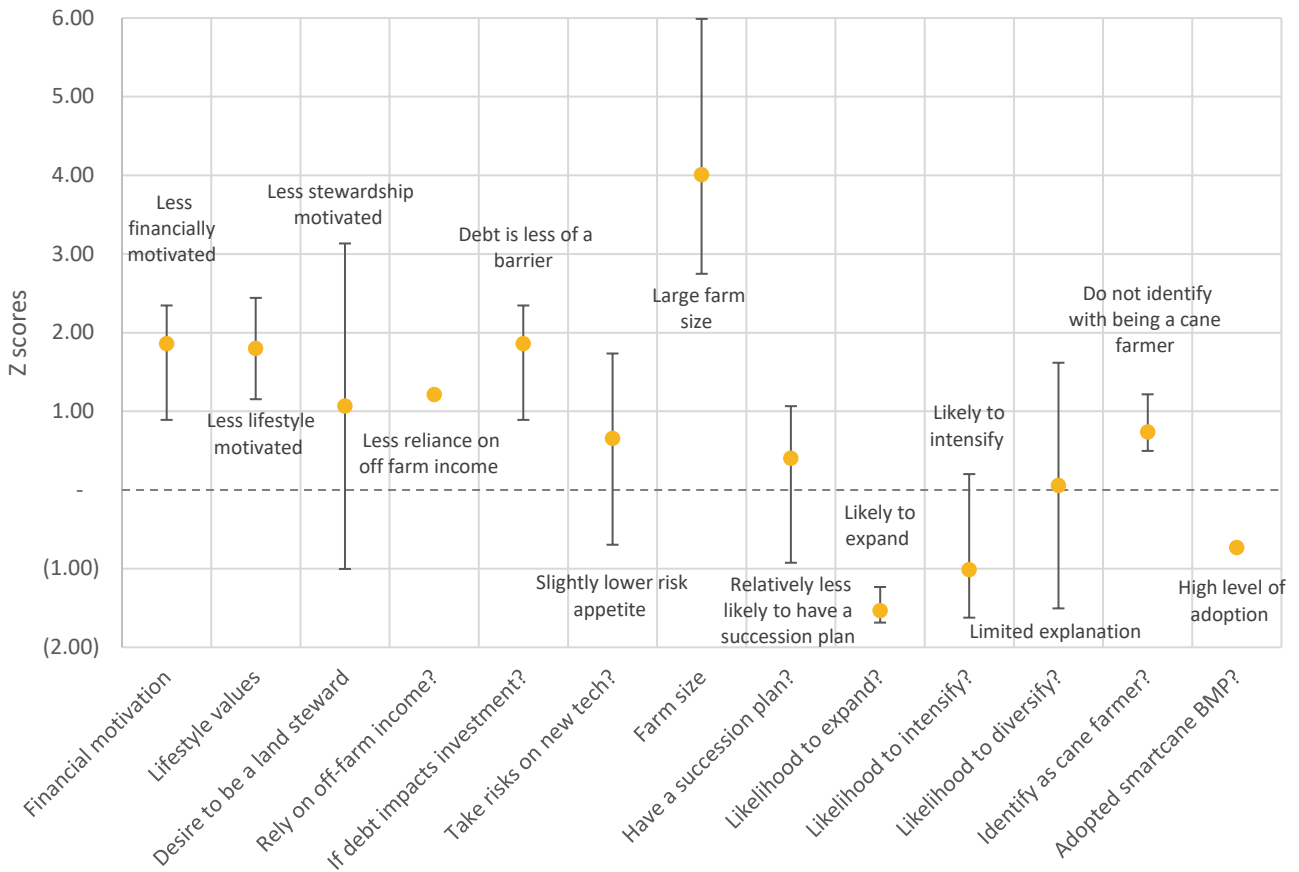


Figure 5. Cluster 4 z-scores

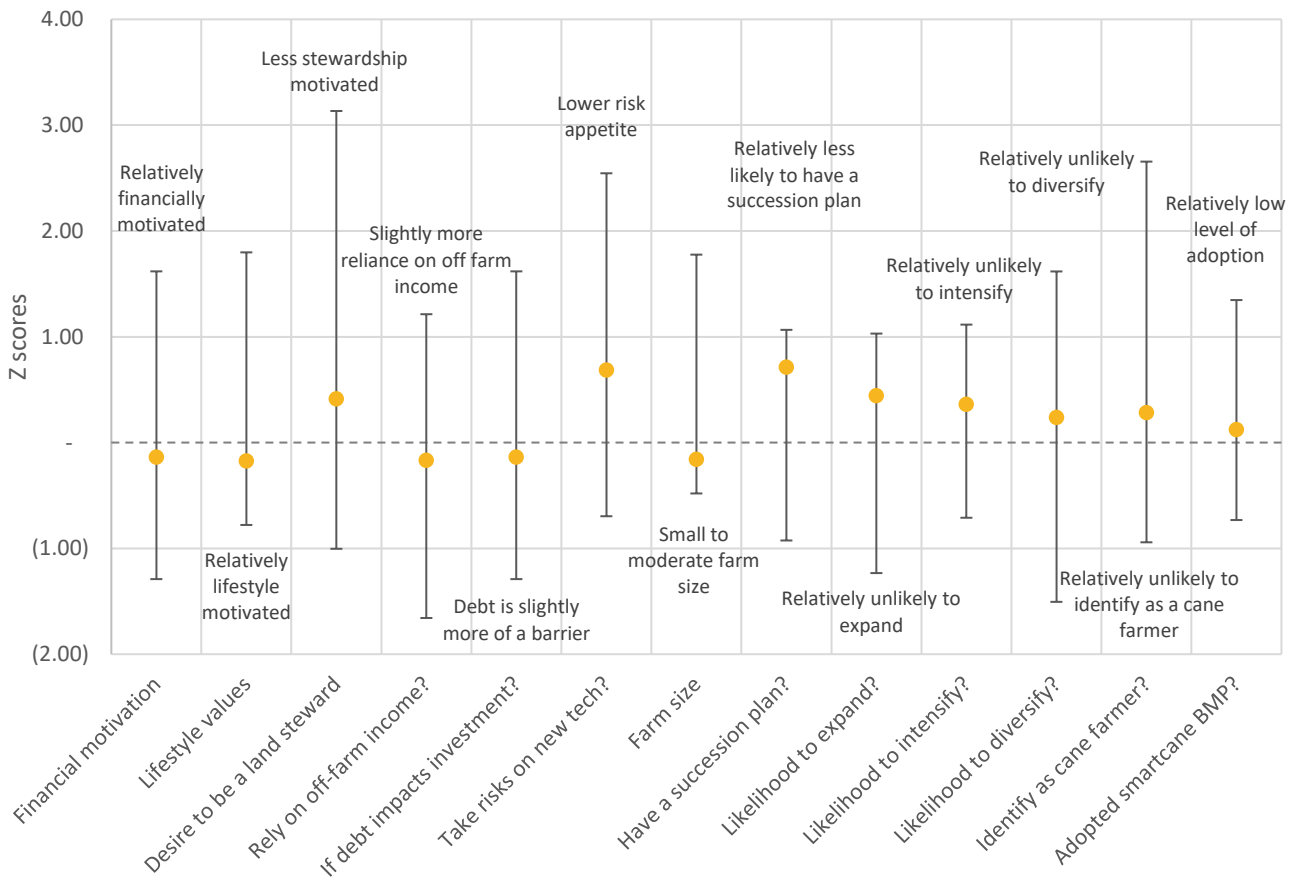


Figure 6. Cluster 5 z-scores

The cluster groups were then described and compared to NCE’s original typology. There was some alignment with the original typology; however, the comparisons were not perfect. Table 3 presents the names and descriptions of the original typology; along with the new cluster groups that best align with them, and their descriptions.

**Table 3. Comparison of typology and clusters in data**

Type	NCE (2020a) typology (developed qualitatively through literature review and interviews)	Closest cluster group	Future of Farming Survey data typology (data based cluster group description)	Cluster proportion of dataset
Traditionalists	High ‘production-ist’ value, lower levels of innovation. Tended to have low levels of financial capacity, smaller farms, highly motivated to keep the farm in the family. Tend not to be involved in agri-environmental schemes. Low trust in government programs.	Cluster 5	Cluster 5 farmers are more financially motivated and are relatively more lifestyle motivated. They agree that they rely on off-farm income and that debt impacts their ability to make investments. Cluster 5 farmers possess a small farm size, are relatively unlikely to expand, intensify, or diversify their farming operations and have low adoption levels of BMP. However, Cluster 5 have low rates of succession planning and were relatively unlikely to identify with being a cane farmer.	30%
Experimenters / Diversifiers	Mixed crops, high risk threshold, high trust in government programs.	Cluster 2	Cluster 2 farmers like to take risks on new farming technology and are likely to have a succession plan in place. Cluster 2 farmers agree that they identify as being a cane farmer and appear to have high adoption levels of BMP practices.	35%
Enterprise farmers	High financial capacity, no off-farm income, large farms, strong profit/expansion values, high risk threshold. Mixed trust in government programs.	Cluster 4	Cluster 4 farmers possess the largest farm size. They are less financially, lifestyle and stewardship motivated, and disagree that they rely on off-farm income and that debt impacts their ability to make investments. Cluster 4 is likely to both expand and intensify their farm and disagree that they identify as being a cane farmer. High adoption of BMP.	5%
Conservationists	High environmental values, small farms, no off-farm income, high engagement in agri-environmental programs. High trust in government programs.	Cluster 1	Cluster 1’s on-farm decision-making is considerably less financially motivated. Cluster 1 is also significantly less motivated by opportunities to benefit from the farming lifestyle but is more motivated to be a land steward. Cluster 1 typically possess smaller farm sizes; they disagree that debt is a barrier to investment and tended to have less reliance on off-farm income. Cluster 1 relatively disagree that they identify as a sugarcane farmer and rely on off-farm income.	18%

			BMP adoption within this group was relatively low.	
Lifestyle / hobby farmer	High incidence of off-farm income but low financial capacity, strong lifestyle values, low risk threshold. Mixed trust in government programs.	Cluster 3	Cluster 3 are relatively lifestyle and financially motivated, and also stewardship motivated (to a lesser degree). They agree that they rely on off-farm income but also that they like to take risks on new farming technology. Cluster 3 is unlikely to expand, or intensify, but are relatively likely to diversify their farming operations. They had slightly higher rates of succession planning and BMP adoption within this group was relatively low.	12%

Out of the original NCE typology, the traditionalist type had a close fit, with Cluster 5 including farmers who are relatively financially motivated, have low financial capacity, small farms, and low adoption of BMP.

The enterprise farmers had a good match in Cluster 4, which included respondents with large farms who did not rely on off-farm income, did not identify with being a cane farmer, and had plans to either intensify or expand. However, they did not appear to be strongly financially motivated which does not match well with the enterprise landholder type.

Experimenters and diversifiers also had a fairly good match in the k-means clustering results with Cluster 2, which had farmers who like to take risks on new technology and have high levels of BMP adoption; however, Cluster 2 did not have plans to diversify (they may have already diversified but do not have future plans), which is counter to what the findings of the literature review suggest.

Another good match was that of lifestyle/hobby farmers. Cluster 3 had farmers with the lowest farm sizes, who were more lifestyle motivated, relied on off-farm income and were unlikely to expand or intensify. However, unlike lifestyle/hobby farmers, Cluster 3 had a slight appetite for risk, and were relatively likely to diversify.

Conservationists had a less well-matched cluster in Cluster 1. Cluster 1 had farmers who had small farms, weren't financially motivated, weren't constrained by debt, and didn't rely on off-farm income. On the other hand, they didn't have high levels of BMP adoption and were only slightly stewardship motivated, unlike conservationists.

The analysis outlined in this report demonstrates a number of key points relating to the characterisation of sugarcane landholder types. These are as follows:

- **A robust method of determining landholder typology among reef sugarcane landholders has been demonstrated.** The approach detailed in this report provides a feasible and appropriate method for profiling sugarcane landholders. It is also robust and repeatable - with appropriate data (e.g. data that represents the key landholder characteristics and factors that shape practice change adoption), the approach taken in this report could be applied towards different commodities and different farming regions.
- **The method demonstrated validates the typology previously developed.** The clusters identified in the survey data had many similarities to the landholder typology developed from the literature. This indicates that they are reasonable characterisations to use for improving the effectiveness of program delivery by assessing the suite of policy options and how they relate to the different landholder types. It should be noted that some landholder types were not matched as well as others with the cluster analysis. This may be a result of the dataset used missing the 'trust for government' indicator or the small sample size and could be revisited if additional data is collected in the future.
- **Quality of data has the potential to be improved.** To overcome some of the limitations and improve the outcomes of any subsequent analysis, effort should be taken to improve the quality of data for profiling sugarcane landholders. The collection of a consistent and comparable dataset for the relevant variables that

could be analysed at the individual response level would considerably improve the outcomes of this type of analysis. This may include collection of data on indicators beyond those used in this analysis.

## 3 Qualitative data approach

### 3.0 Background

Given the limitations with the quantitative data, we identified a need to collect high-quality qualitative insights to supplement the gaps in quantitative data. These qualitative insights were collected through conducting semi-structured interviews with local experts. Local experts were identified as those who have on-ground experience working with landholders in the context of practice change for water quality outcomes.

The purpose of the local expert interviews was to gather insights, from the perspective of delivery providers and coordinators, on the different types of landholders and the engagement strategies and social factors that should be considered when working with different landholders on practice change for water quality outcomes.

The purpose of conducting local expert interviews was to:

- Gather insights from local experts on the types of landholders they work with and the different characteristics of those landholders.
- Gather insights from local experts on the types of engagement strategies used to engage landholders in practice change and the potential barriers and enablers of different engagement strategies across different types of landholders.

### 3.1 Methods

Based on consultation with GBRF, ten local experts were identified. These experts were chosen to provide a broad range of perspectives that included representation across the different regions of the GBR as well as across the delivery network (e.g., regional program coordinators, extension officers and program delivery provider staff).

All interviews were conducted online using Microsoft Teams. In person interviews were not feasible given the geographical locations of the interviewees. Interviews with local experts from the Mackay Whitsunday Region and Lower Burdekin Region were conducted in collaboration with The Social Deck, where both an interviewer from The Social Deck team and Dr Anne Cleary attended the interview with The Social Deck team member leading the interview supported by Dr Anne Cleary. Interviews with stakeholders from other regions were conducted by Dr Anne Cleary alone.

Interviews were approximately 45-60 minutes in duration. Interviews were semi-structured (see interview guide in Appendix A). Questions about engaging with landholders were asked in the context of engaging landholders in practice change for water quality outcomes. All interviews were audio and visually recorded and transcribed using the Microsoft Teams auto-transcription function. Interviewees were invited to participate via email correspondence with information on the study provided to the interviewee prior to the interview. All interviewees provided verbal and written consent to participate in the interview and have it recorded and for the results to be reported anonymously. A coding frame was developed that was structured on the ecological systems theory (Bronfenbrenner, 1992), where themes and codes were developed to represent the different system levels. The system levels included in coding frame are as follows:

- the individual level (individual landholder demographic factors or individual farm characteristics),
- the microsystem level (immediate environment such as the landholder's relationships with other people),
- the exosystem level (social structures that have influence over micro-systems, for example, the landholder's engagement with the farming sector); and,



- the macrosystem level (socio-cultural elements, for example, how broader environmental changes and policy landscapes affect the landholder).

This systems-thinking approach helps with recognising that landholders do not exist and behave in isolation but rather that landholders, both their behaviours and social outcomes, are shaped by the interactions between the levels of the system in which they exist.

Using the approach described by Braun and Clarke (2019) we conducted thematic coding of interview transcripts with sub-codes being identified to capture different sub-themes within each ecosystem level. For example, while the thematic coding would begin with coding the qualitative data based on a system level (e.g., microsystem level) various sub-themes within this level would be identified during the coding process (e.g., relationships with peers, relationships with family, relationships with extension officers). Dr Anne Cleary conducted the thematic coding which was cross-checked by Mette Kirk.

## 3.2 Results

The results are structured based on each system level and the sub-themes identified within each system level. Supporting quotes from local experts are included with the quotes anonymously reported using the following unique identifier codes; 'local expert 1', 'local expert 2'.

### 3.2.1 Individual level factors

Within the individual level there are two types of factors to consider; those factors that relate to the individual farmer (e.g., age, education level, digital literacy, personal values, attitudes and goals) and factors that relate to the individual farm (e.g., farm size, farm location/remoteness and farm environmental condition [e.g., soil condition]). In the following sections we discuss these factors across the sub-themes of:

- Understanding landholder goals and their practice change journey
- Stress levels and mental health
- Landholders who are exiting the industry.

These sub-themes were identified through thematic coding of the qualitative data within the theme of individual level factors.

#### Understanding landholder goals and their practice change journey

It is clear from interviewees that, when engaging with landholders, you need to meet the landholder where they are with regards to their practice change journey. Some landholders may be ready to engage at the 'pointy end' (Local expert 1) of precision agricultural practice change, whereas other landholders may just need the basic support to enable them to meet regulations.

*"[you need] to cater for different demographics of cane farmers, so you got [some projects] that sort of a bit more in the pointy end of the spear in terms of more innovative practices looking at variable rate within paddocks, looking to really refine some of those practice changes and...then there's the other end of the spectrum [with projects] doing a good job engaging with a lot of their growers and to be able to, I suppose start people on that that pathway to adoption"*

(Local expert 1)

Interviewees described how it was important to understand landholder's goals for their property as this will inform how to tailor the engagement and practice change to enable uptake by the landholder. The following quote demonstrates how the interviewee uses an understanding of the landholder's goals and motivations to tailor the language and project to best resonate with the landholder:

*“If they say productivity is their main focus then I might do a plan a little bit differently than if economics and efficiency is the main driver. Like if productivity is their main driver, then I'll probably try and find ways to increase their productivity because I know it's going to be really hard. Like I'll find some ways to cut their fertiliser that they're applying, but I'll really be looking at things like disease and how they're managing their older ratoons and looking for opportunities where we might be able to increase productivity. And if they say they're interested in the technology side then we'll prioritise them for mapping and we might like we have a little bit of funding to help people get a rate controller, so we'll like we'll be thinking about them for that. And most people say they do care about environment as well. But if they like specifically leave that off [don't select on the onboarding form] then we won't talk about it [water quality/the environment] to them.”*

(Local expert 6)

Understanding where landholders sit along the practice change journey and their goals for their farm may be informed by individual landholder characteristics such as farm size or age and life stage. However, these characteristics are not one size fits all, and while some landholders with smaller farms may behave a certain way, this won't be the case for all landholders with small farms. For example, most local experts talked about the age and life stage of the landholder as an important consideration when looking to engage landholders in practice change. But, again, there was no set rule for how landholder age affected their willingness to engage and uptake new behaviours. For example, some local experts described how younger growers tended to be more responsive to innovative approaches and uptake of new technologies:

*“The requirement for technology moving forward is that they [older landholders] can't keep up with it and that's for the older ones and then you get the younger ones who can be quite technical.”*

(Local expert 8)

However, this was countered by some local experts describing how older landholders who were nearing retirement could experience renewed motivation for wanting to improve practice:

*“there's older farmers who, you know, some people get to towards the end of their life and realise that they could have done things better and they've got a real push for technology and they've, it kind of surprises you when you go to their shed and there's a 67 year old fella who's just got the latest technology installed on their fertiliser box and they're really proud of it and they wanna work out that they and their kids are in the business and you know. Yeah, so I don't think it's one size fits all.”*

(Local expert 5)

Similarly, a sense of leadership and legacy among older landholders can be an important social factor to be considered when engaging with particular landholders:

*“Like some of the old people have viewed themselves as a leader from always and ... I guess that's how they see themselves, and so they have kind of continued a little bit to be a bit more progressive and it's part of that image they have of themselves and what they want other people to see them as well”.*

(Local expert 6)

One challenge with younger growers is that they tended to be very time poor, limiting their capacity to engage with programs and practice change. This was particularly the case for landholders who were raising young families or who sustained an off-farm income and managed the farm outside of the working hours of their other job. This issue of being time poor was also identified with landholders of large farms who often worked as contractors to other smaller farms.

Other characteristics such as farm size, time and resources were identified as key landholder characteristics influencing practice change and how far landholders were willing to go on the practice change journey:

*“There is a spectrum of growers. And I mean it comes through in how well they maintain their headlands and how you know how much time they have and how much land they have as well.”*

(Local expert 1)

Given the different landholder characteristics and variables it was questioned how useful it was to try and define different groups of landholders based on these characteristics, particularly given the diversity in ways that these variables might be expressed across different landholders and even how variables might change over time or under different circumstances:

*“There are so many variables, there's no way you could shoehorn people into a box because it could be that they don't have the financial capacity, or it could be that they just aren't interested because they just want to keep it simple. It could be that they're retirees, and they don't have young kids... You know there's a whole or any mix of those.”*

(Local expert 2)

### **Stress levels and mental health**

One individual level factor that is worth noting are the individual stress levels and the mental health of landholders. Experiencing high levels of stress, anxiety or depression will adversely impact on landholder's capacity to undertake practice change. Multiple local experts acknowledged the increasing levels of pressure and stress that landholders are currently facing. These increasing pressures were considered to be typically driven by factors outside of the landholder's control (market conditions, regulatory environment, weather):

*“Usually, those pressures come from some type of regulation or you know, public push for something, um, the weather is obviously a major contributor to stress, they can't control that. So, there's always things they can't control. But I do feel like that a lot of this stuff in regards to the Reef and regulation has created a whole lot of additional stress for them that they didn't have before.”*

(Local expert 8)

While individual pressures by themselves may be manageable, it seems to be the cumulative effect of multiple pressures together that are causing increased levels of stress among landholders, resulting in what can be a difficult time for landholders:

*“There is increasing stress... you can see it on their faces. You can see it in their responses when they talk to you. Everything is a problem like it becomes everything has been driven by this or that or something else and ... I don't think they're coping with all the additional pressures as well as they used to just because there's so many more of them now.”*

(Local expert 8)

As one local expert described in relation to the increasing stress and pressure she noticed among landholders, particularly recently:

*“It's awful out there. It is awful.”*

(Local expert 9)

### **Landholders who are exiting the industry**

One interviewee highlighted landholders who have planned to exit the farming sector as a potential group of landholders who will be difficult to engage in practice change. This group of 'exiting landholders' may be important to consider as they may not have any motivation to implement practice change on their farms during their remaining time as landholders and may present a challenge for water quality outcomes, particularly if numbers of exiting landholders grow. Conversely, another interviewee highlighted that while a lot of landholders are near retirement age these transitions tend to be slow and there is still merit in engaging landholders even if they are approaching the end of their career as canegrower:

*“When I first started, I remember someone saying, well, it's good you've started this job because you know where all the farms are gonna sell like, these guys are all old, they're all going to be moving on soon and they'll be a whole lot of change going on. And that was ten years ago and I'm still talking to the same people now”*

(Local expert 10)

### 3.2.2 Microsystem level factors

The microsystem level refers to things which have direct contact with the landholder in their immediate environment and often refers to individual relationships. Within the microsystem level we identified three distinct types of relationships that play a factor in landholder's practice change behaviour:

- Relationships with family
- Relationships with peers
- Relationships with extension officers

With regards to family relationships that shape a landholder's practice change two types of relationships were predominantly discussed; the landholder's relationship with their spouse (typically their wife) and the landholder's relationship with their children or other family members (typically an older son who is involved in the running of the farm). We discuss each of these relationship types and their role in shaping practice change below.

#### Relationships with family - spouse

Spouses/wives were identified as a key driver of a landholder's decision making around practice change, particularly among older growers and where the practice change required skills in administration, budgeting, paperwork or office/computer-based work. Wives were often identified as 'working behind the scenes' playing a key role in managing the farm finances and administration.

*"With them [older growers], most of their wives do all the computer work. So that is also an important point to note. When you're doing stuff with older growers, it's probably better to include their wives because you'll find that they are the ones doing the most of the, you know, computer stuff, more technical stuff in the background, not with the farm, not outside on the farm so much, but definitely in the office. It is the women who are doing all the work, so you know, trying to target growers in regards to developing budgets and stuff, maybe they should be targeting the wives to be a part of that because they're the ones that sort of do that stuff more."*

(Local expert 8)

With older growers, a number of local experts described how typically the wife may have a higher education level than the landholder or have professional experience working in office/computer-based environments:

*"Often, it's the wife that does a lot of these things [office/computer-based work] ... that's just how it is in a lot of situations, because a lot of these guys often didn't go well at school. They went to school, but dropped out, right, like you dropped out in Grade 9 back then to do an apprenticeship at the mill or work on the farm or an apprenticeship on a mine or something when they were younger. You know, like never really had to do it [office/computer-based work] and they it's either the wife does it or an accountant does it."*

(Local expert 10)

Including the spouse in discussions around practice changes that have financial implications could be beneficial and avoid situations where there is disagreement or conflict around the practice change in the landholder's household:

*"If you can get the wife involved, even better! She's normally working off farm, she's often doing the accounts, so she's like 'oh you could be saving some money doing things that way [e.g., reducing fertilizer application rates] because you're talking to the family because money is a family thing."*

(Local expert 6)

#### Relationships with family – other family members

In some cases, cane farms are family operated where sons and daughters are involved in the farm management, or they own other cane farms in the same region as the landholder:

*“What you'll often find is a family unit might have a farm and then the son might have a small farm over on the side of his own or something like that. Yeah, sometimes if the kids are there, like they might sit in like sometimes I do two together, like the son has a farm and the father has the main farm and then we might sit down all together to work out what's happening because they still sort of work it all together.”*

(Local expert 8)

In these cases, where there are multiple family members involved in the cane industry, it is important to be aware of the dynamics between these family members and potential opportunities to better engage with landholders through considering these family relationships. When engaging landholders, it is important to be aware of the family dynamics and identify when it may be beneficial to engage with other family members as a way to better communicate and transfer information. However, this will require a good understanding of the dynamic and nature of the relationships between landholders and family members and should only be considered where there is confidence that the relationship is mutually respectful between the landholder and family member, otherwise there may be negative consequences where the relationship between the landholder and extension officer is compromised as they are seen as overstepping boundaries:

*“There is this one farmer I work with where I'm like ‘how about we hand over the fertiliser to your son?’, because we could do so much more because the young fella is keen and the old fella is like ‘this is not gona work for me’...but even that over time if you just maybe when you get a chance spend a little bit of time with the younger one and give them some information to feed to Dad when you are not there, as long as they have a respectful relationship with each other.”*

(Local expert 6)

With older growers, there may also be relationships with grandchildren to consider. These relationships may provide motivation for older growers to consider and care about their legacy and broader impact of their farms:

*“Most of the people that I work with really care about is their grandkids. They talk to me about their grandkids a lot and don't miss anything to go and see the grandkids or to pick the kids up, so I don't know if there's something in that in terms of caring about the bigger picture?”*

(Local expert 6)

## Relationships with peers

Relationships with peers and the distinct identity of the cane growing community was identified as a key determining factor of practice change.

*“Very community minded amongst the growing community ... because it's sugarcane you're not competing against one another whereas in like horticulture or other businesses you're competing, you know your neighbour is selling for the same thing and so you know it actually matters what they do but in sugarcane they all go to the sugar mill, so you're competing against the sugar mill basically. So, there's a fairly strong community, I'd say, more so than any other agricultural sector, just because they all have to work together because of how the harvesting is set up.”*

(Local expert 10)

This sense of community and connection among landholders will have important implications for landholder's willingness to adopt new practices, particularly in cases where the practice change may make the landholder 'stand out' and where the landholder places high importance on belonging to the community. Similar findings have been demonstrated by Hasan et al., (2021) who conducted face-to-face survey with 248 sugarcane growers in the Wet Tropics. Hasan found growers were less likely to change fertilizer practice if they regarded maintaining good relationships with other local growers as being extremely important.

Several local experts observed that what an extension officer hears from a landholder during one-on-one conversations can be different to what they hear from the landholder when they are in a group setting with their peers. This again highlights the important role that a landholder's relationship with their peers plays in shaping practice change.

*“You've also got to understand that there's what growers tell you in private and what they want to be seen to be saying when they're, you know, when they're under the gaze of other industry members, they're vastly different.”*

(Local expert 2)

Interestingly, while standing out by doing things differently on their farm may be perceived as negatively impacting landholder's connection with their growing community, other local experts observed that there was growing stigma around being branded as a 'bad grower' which can have ramifications for how growers are accepted by their peers and growing community. One interviewee described how it was important to move the conversation beyond 'finger pointing' to getting landholders to view it as a shared problem:

*“I mean, there's always 'he said this' or 'he did that'. It's like a schoolyard some days... but you know it's again data has shown it's a shared problem here... You know, I cannot fingerprint one industry as a result of these data...it has changed how people perceive or they're kind of engagements with projects to realize it's more a shared problem. Now you hear the words we are friends and neighbours. Let's just get this sorted.”*

(Local expert 9)

In addition to the relationships between landholders, the overall mindset and culture of landholders and their peers was also identified as a key consideration when looking to implement practice change. One local expert described that while change does happen among landholders, it tends to occur more slowly and gradually than what might be anticipated by practice change initiatives

*“So, they've seen a change over the years, but they don't like it happening like quickly. They like it happening slowly so they can plan for it.”*

(Local expert 10)

It is important to consider the potential mismatch between the timeframes in which landholders tend to implement change and the timeframes in which discrete projects are funded and implemented and how this might affect the landholders' willingness to engage, particularly in the case of older growers:

*“they're born on the farm and they're 70 now, like change doesn't happen for them much, I guess. Change happens around them, but there are constant in the middle of the world changing around them and with the water quality work, they just see all these people coming and going and project starts and a project finishes and they don't know the*

*difference between the six different projects that are going on and that sort of you know, I think they just watch it and wait for it to disappear.”*

(Local expert 6)

Similarly, while the lifespan of individual projects may be relatively short (based on funding cycles) the challenge of addressing water quality issues in the Reef requires sustained support to deliver long-term, sustained change:

*“This is a long-term problem. This is like the solution is long term management practise challenge. It's sustained change, it's sustained support over a long period of time.”*

(Local expert 10)

Finally, the culture of landholders was described as ‘conservative’, which can result in landholders not responding well to be told what to do.

*“Socially the community is very, very conservative, as you'd imagine...don't like being told what to do.”*

(Local expert 10)

These peer relationship factors point to a strongly connected community that will potentially be slow to behave in ways that they perceive as ostracizing them from their community and who prefer to implement change over longer timeframes and are unlikely to show high willingness to take up sudden changes, particularly when it is something that is not their own decision but something they are being told to do.

### **Relationships with extension officers**

Across all interviews the importance of the role of the relationships between the landholders and extension officers was emphasised as a key driving factor in supporting practice change. It is important to note that several interviewees were themselves extension officers, which may result in somewhat positively biased view of the role of extension offices. However, the importance of the role of extension officers and the relationships they form with landholders has been reported elsewhere, particularly in the grazing industry (Rolfe et al., 2021, Coggan et al., 2020), which supports the insights we discuss here:

*“It's all about relationships and developing those networks and you know the support and getting the grower comfortable that they can just pick up the phone and give you a call.”*

(Local expert 1)

The relationships between landholders and extension officers that were considered to be productive were those based on mutual trust, respect and honesty, with time, particularly one-on-one time spent on the farm, often being cited as a key factor for helping to build these trusted relationships:

*“They [extension officers] need to be present. They need to be honest... and they need to be humble... you know you need respect for [the landholder], you need to like, this person knows their farm better than you do, no one else knows it as well as they do. No one else has the history of what's going on. Yeah, and no one else can set their goals for them...sometimes it takes a really long time to work out what those goals are.”*

(Local expert 9)

Having a good relationship between the landholder and extension officer isn't about making friends with or being popular with landholders, rather it is about establishing a relationship where landholders can be encouraged and challenged outside of their comfort zone and to change their own ‘status quo’ of practice:

*“Sometimes you do have to push hard and push the boundaries. And yeah, you're not their friend. It's not a friendship relationship. There was a program where you could see that they just they wanted to be the farmer's friend, you know? ‘Yes, yes, yes, we can help you do that. Yes, we can help you do that. Isn't that wonderful?’ That's not actually being his [the landholder's] friend, that's just agreeing to let him staying as status quo. Being his best friend is pushing the*

*boundary and going, no, you can't do that. You know that doesn't work and having the confidence in what you do to be able to, you know to push hard like. You know, our job is not to walk around and say, I've got 200 friends out there, you know, our jobs to say, you know, I've helped these guys, you know, improve what they do."*

(Local expert 9)

It is important that the relationship between the landholder and extension officer is authentic, and that landholders aren't made to just feel like another number in a project used to meet project milestones.

### 3.2.3 Exosystem Level Factors

The exosystem level refers to the formal and informal social structures within which the landholder resides. In the context of this work the social structures are those which make up the cane growing sector, for example, industry organisations, the industry workforce and delivery network and the industry narrative or media discourse. Across these social structures within the exosystem level factors we identified the sub-themes of 'trust and leadership' and 'workforce demand and supply'.

#### Trust and leadership

Several local experts mentioned the challenge with the sense of mistrust landholders had about 'Reef science'. The work of Peter Ridd since 2018 was a key contributor to fuelling this mistrust which has left a lasting legacy of landholders mistrusting science and government regulations. It has also caused contention and division within the cane farming sector which has been counterproductive to supporting landholders in practice change. A number of local experts mentioned that they had noticed landholders feeling somewhat frustrated with the sometimes conflicting messaging and lack of apparent unity across the cane growing sector. As one local expert described this could lead to the ultimate detrimental impact of landholder losing 'faith in that industry body':

*"It can be a little bit conflicting between different organisations and because they have their own issues with each other, I think the growers are starting to pick up on a lot of that and I think they're getting very frustrated by that. It would be nice to have more unity across the industry, across the industry bodies. I think growers can see this stuff happening between the industry bodies and it would be nicer if they were unified in some of these things. That worries me a little, that that the problem with that is it detracts from the growers. What's the word? Not reliance, but I sort of want to say faith in that industry body."*

(Local expert 8)

Some local experts noticed that some landholders were ready to move on from debating the science and the mixed messaging and that there was an appetite for good leadership and clear advice for supporting landholders:

*"People might be getting a little bit tired of it [debate questioning the science] and just want good leadership and clear advice."*

(Local expert 1)

When considering providing landholders with clear advice it is important to consider landholder's 'information diet' (Local expert 4) and where they currently source advice from which often includes local industry media (e.g., The Billet magazine in Mackay and the CaneGrowers Magazine) as well as radio (e.g. the ABC Rural report) and tv media (Channel 7 news).

#### Workforce demand and supply

A number of local experts highlighted that the challenge wasn't just about getting landholders engaged and willing to adopt a practice change but also about having sufficient access to local experts with the right skills and knowledge to guide the landholder in implementing the practice change. For example, there is growing interest among landholders in certain regions to implement automated irrigation systems, however there is a lack of technical skills among local workers to support landholders to design and implement effective optimized automation systems:



“The challenge is not so much the level of interest in automation, it's the for the project that challenges providing the level of service required to respond to that demand that is challenging for them because there are only a very small number of people in the region who are actually technically capable of designing good, optimised automation systems.”

(Local expert 2)

Similarly, with regards to the uptake of new technologies for improving practice change, often there is a lack of local experienced workers to support landholders in implementing and maintaining new technologies, particularly when something goes wrong with the equipment or technology (this is discussed further in section 3.2.4).

“Like there's nobody local to help them through that.”

(Local expert 8)

### 3.2.4 Macrosystem Level Factors

The macrosystem levels is the highest level of the ecological system and includes aspects such as laws, public policy and has been referred to as the institutional level in other Reef related work (Coggan et al., 2021). Our analysis of the interview data led to the identification of three key themes of macro system level factors that shape practice change:

- Market conditions
- Regulatory environment
- Technology and connectivity

#### Market conditions

Market conditions play a key role at the macrosystem level and can present both enabling and inhibiting conditions for practice change. For example, the current high cost of urea has made the practice change of reduced fertiliser application rates much more palatable to landholders who now see high fertiliser application rates as negatively impacting their profitability:

*“Urea prices have gone nuts. They're not gonna come down anytime soon. And so, all of a sudden there's demand from growers to cut N... growers do want to reduce their N rate if they can, and but they want to maintain yield or increase their yield”*

(Local expert 2)

However, two local experts discussed how landholders tend to be at the mercy of market conditions with no ability to control the cost of inputs or outputs (e.g., sugar costs):

*“The grower's always at the bottom, they don't get to set the price and they don't get to charge more. So, every time something comes in where it costs them more, so this is a new thing that costs them more, that's an annual additional cost to them and if everyone keeps doing that, the grower, all their profit just keeps getting eaten away and, in the end, somehow they have to grow more or get more.”*

(Local expert 8)

*“We're price takers, so we don't get to say I'm going to sell my product for more as well. You know, we just get told this is what you're gonna get paid for that and, by the way, and here's all your input costs.”*

(Local expert 9)

#### Regulatory environment

Local experts from one region described how the recent occurrence of auditing in their region had served as a driver to landholders engaging in their programs.

*“A bit of that [engagement] is driven by their concern about being audited for the regulations, [and landholders] wanting that support... they're getting in contact with us because they've been audited by the 'Reef police'...or because they are afraid of being audited and they're just not up to scratch...Up until March, that [fear of being audited] wasn't a real driver for engagement, it was only when they just started actively auditing.”*

(Local expert 5)

### **Technology and connectivity**

While there have been technological advancements in the cane industry (e.g., GPS, equipment) there are a number of barriers to the effective implementation of these technologies. These barriers include:

- Access to secure and affordable internet connection to support new technologies
- Access to local expertise to provide hands on support in implementing and troubleshooting new technology
- Cost of buying and maintaining new technologies

Many landholder properties are in remote locations with poor access to secure internet connection. Increasing the quality of the internet connection often comes at an additional cost:

*“[With] technology comes all these things. So yes, variable rate is one thing but then they need to have connectivity. So, if they can't connect, they can't use the equipment like there's all these series of problems associated with the things that we're trying to get them to implement, but then that's an extra cost, so instead of paying \$40 a month for internet, all of a sudden they're up to \$200 a month for internet to try and get connection.”*

(Local expert 8)

In addition to the connectivity issues, having access to local hands-on support to help landholders implement and make the most of the new technology is often lacking:

*“Like there's nobody local to help them through that. Like they buy it, they might buy a piece of equipment, the person sells it to them, they've got an idea about what it does, and they can do a bit, but usually they might come out and go, oh, I don't know about that. And then they've got to ring someone who's in Brisbane or somewhere else who's in the wherever and that person might try and talk them through it online. That's it's not the same. What they need is people to be able to come in and have them sitting there and go, this is what you need to do. This is what it can do and show them because that that is how they learn so. Mostly growers are hands on so having a zoom and saying you need to do this, this, this and this. It doesn't stick.”*

(Local expert 8)

### **3.2.5 Understanding the social system of practice change**

We have summarised the findings of the interviews as well as the quantitative findings (Section 2) to develop an ecological system of practice change among canegrowers (Figure 7). Figure 7 presents that social system of practice change as informed by the interview findings and previous research in this space. This provides useful context when engaging with landholders on practice change.

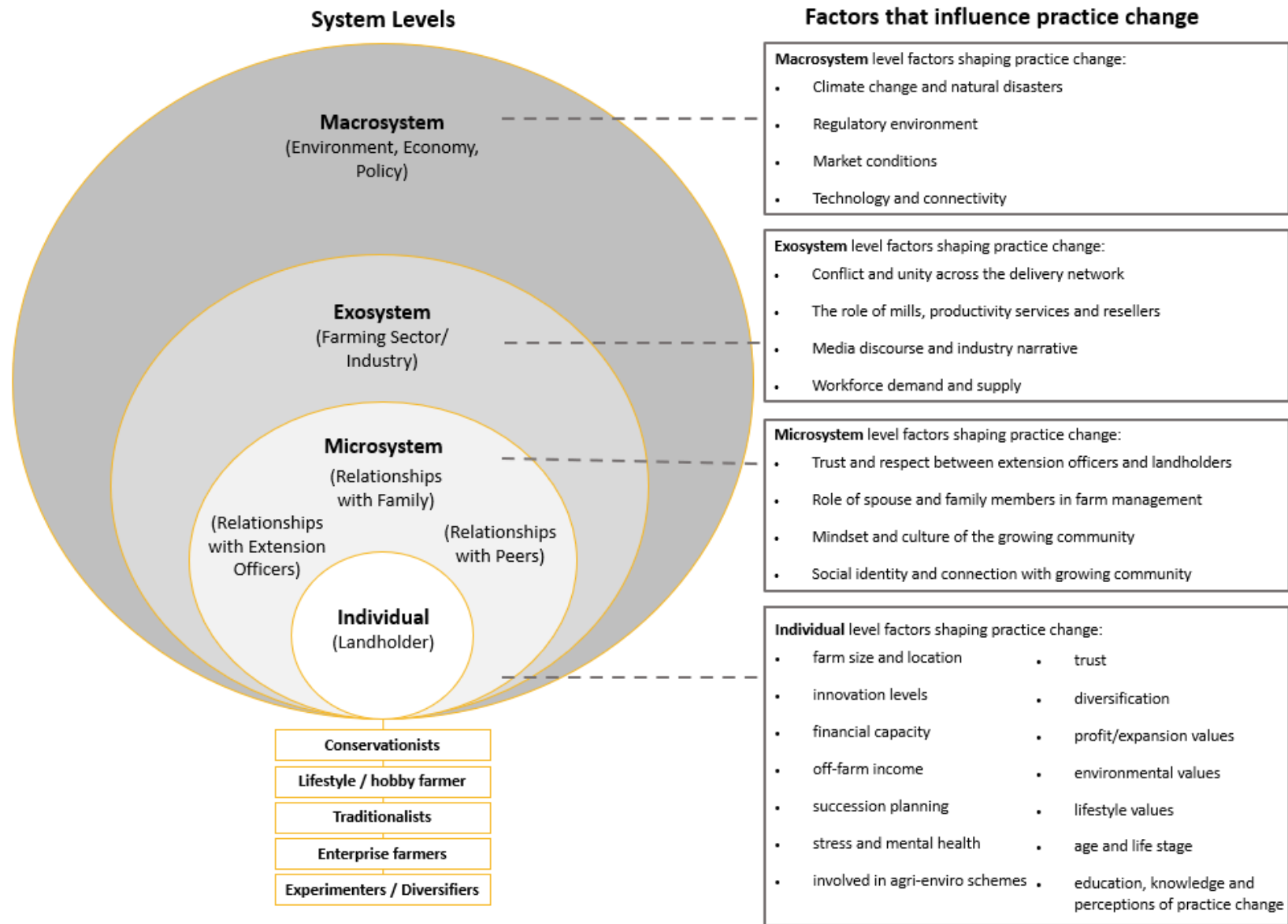


Figure 7: Factors influencing of landholder practice change across ecological system levels

## 4 Identifying engagement approaches

The aim of this research was to build understanding of the social context of landholders and to identify different types of characteristics and profiles that exist among different landholders. These social insights could be used to better inform the design of tailored engagement strategies helping optimise engagement with, and the effectiveness of, the regional water quality programs and projects.

The findings of the cluster analysis support the hypothesis that different profiles of landholders exist that can be characterized based on individual factors such as farm size, financial capacity, off-farm income, innovation levels, succession planning, involvement in agri-environmental schemes, trust for government and science, diversification and the landholder's values towards the environment, profitability and lifestyle. However, the interviews with local experts painted a much more nuanced picture of the complex social system in which individual landholders are situated. The findings from the qualitative analysis reaffirm that a one-size-fits all approach is not appropriate when engaging landholders. Rather our findings suggest that while different profiles of landholders exist, it is not recommended that these profiles be applied in a prescriptive or rigid way, but rather that they be used to develop guidance for supporting extension officers to tailor engagement to match the particular profiles and social contexts of individual landholders.

We have used the findings of this research to inform approaches to landholder engagement. It was clear from the interviews that there is no such thing as 'one-size-fits-all' when it comes to landholder engagement. A diversity of engagement strategies is needed to suit different types of landholders as well as to suit the different stages of the practice change journey that each landholder is on. Whether engaging landholders to adopt advanced practice change behaviours or introducing landholders to practice change for meeting regulations, there are a number of engagement strategies that can be employed across a spectrum of direct one-on-one engagement between landholders and extension officers through to small and large group engagement with peers and industry. Engagement strategies don't need to be an either-or approach but rather can build on one another with landholders deriving different outcomes from different types of engagement strategies.

Engagement strategies refer to the mode of engagement (e.g., one-on-one, small or large group engagement, online engagement) and engagement approaches refer to the language and story that is communicated during the engagement strategy. Importantly, as our research findings highlight, engagement approaches need to be aware of the different social factors occurring at the microsystem, exosystem and macrosystem levels and how these factors may be affecting the practice change opportunities at the individual landholder level. Engagement approaches therefore need to be responsive and flexible allowing them to be readily tailored to changing circumstances across the social system.

Different engagement approaches can be used across the same engagement strategy depending on what is appropriate for the landholder being engaged. We have used the collective findings from the quantitative analysis (Section 2) and the local expert interviews (Section 3) to identify four engagement approaches that can be applied as part of engagement strategies:

- Approach 1: Telling the whole story
- Approach 2: Profitability and productivity
- Approach 3: The good growers
- Approach 4: Hope for the future

In the following sections we describe each of the engagement approaches and summarise by providing commentary on how these engagement approaches might be applied across the different landholder types as identified in Section 2 (Table 4).

## Approach 1: Telling the whole story

Most local experts talked about the need to be holistic when engaging landholders and not just focusing on one specific thing. This can be challenging as a project tends to have specific objectives (e.g., reduced DIN rates or pesticide application).

*“One thing that I think kind of makes it difficult is when you just like focused on one thing. Like a farm is a holistic thing...it's not just about nitrogen, it's not just about pesticides and I think when the project is really specifically just focused on one input rather than good holistic management, it can be easily criticised.”*

(Local expert 6)

However, it is important to understand landholder's goals for their whole farm and articulate the benefits for them of participating in the project/practice change. Even if the focus of the project is on reducing nitrogen rates, this outcome can still be achieved without making nitrogen rates the core focus of the engagement with the landholder:

*“So, what I try to do within the projects, everything that I work on is always find the benefits for them and put that front and centre so they can see a benefit and then make the tweaks to the nitrogen is more on the side than actually front and centre.”*

(Local expert 8)

It is important to consider what management practices the landholder is currently implementing and identify opportunities where the new practice change can be integrated within existing the landholder's existing management practices:

*“It's about the whole system that works together, you know. Rarely does a farmer go out and do one thing, you know, he'll be doing a couple of things at once. It's not just one activity and you're doing it for a variety of reasons...so you need to understand the whole system and how everything links together and changing one thing it's going to have a flow on effect... so you need to make sure that nothing else is limiting production, then you can get nitrogen rate, but the focus has been on nitrogen rates, so all the other nutrients or farm management have been left slip because all the advisory staff are just so focused on meeting this one requirement.”*

(Local expert 9)

Landholders also tend to be more interested in hearing the 'whole story' as opposed to just information on reduced rates of nitrogen but instead it is useful to situate that practice change within all the other supporting practices that may be occurring:

*“Farmers do like that whole story helps them get a much better picture of what's happened and where it can benefit... there is enough messaging out there, but I think sometimes it's the detail behind it that actually is a bit more important. So, you'll see this farmer dropped his end rate and it went really well, but then you find out that he also put lime on, he also used a bit of mill mud and he improved his weed management...and it's when you start to get that whole picture that growers start to be at a bit more like ohh yes, let's see.”*

(Local expert 3)

When using this approach when engaging with landholders consider the following:

- What are the landholders' goals for their farm?
- How does the desired practice change integrate with other management practices the landholder is already implementing? Where can there be efficiencies and time savings?
- What types of benefits would the landholder be most interested in hearing about (cost savings, time savings, increased productivity, innovation and technology)?

## Approach 2: Profitability and productivity

While certain landholders may depend on off-farm income, ultimately, every landholder is running a business with their farm and as such connecting the practice change to the profitability and productivity of the farm is critical.

*“But what I fear it seems like people expect them [the landholders] to do that [practice change] just for the good of whatever, but they're running a business they've got, you know, they need to make a profit, otherwise they can't run that business at all.”*

(Local expert 8)

While the current high of urea is making it easy to demonstrate the cost savings of reduced nitrogen application there is still concern and reluctance among landholders with regards to reducing nitrogen rates as it is perceived as negatively impacting their productivity. Within this approach the language that is used is particularly important:

*“The language that we use is just incredibly important. The way we go about, even the absence of sort of some words is probably more important than actually using them...we just don't talk about how different it [nitrogen rates] is from previous to now. We just say, ‘this is what you need’. So, I would be less inclined to highlight, ‘I'm reducing your nitrogen by this much’, I'd be more inclined to say ‘this is how much nitrogen we need and this is what we're using’. So, I think language is the language that you use when you're talking to them is pretty important”*

(Local expert 8)

Also consider any time saving benefits that might be associated with the practice change and communicate this as a cost saving to the landholder:

*“If they can do two jobs in one, that is a cost saving and a time saving because they don't have to go over the ground again”*

(Local expert 8)

When using this approach when engaging with landholders consider the following:

- In cases where the landholder's spouse is involved in off-farm management (e.g., managing the accounts) is there an opportunity to include the spouse in discussions on profitability and productivity?
- Consider current market conditions and how these might affect landholders' acceptance of different practice changes, for example, the current high urea costs make practice change on nitrogen application rates more acceptable to the landholder.

### Approach 3: The good growers

While profitability and productivity are important factors for landholders, they are not the only motivator. Many local experts talked about landholders inherently wanting to do ‘the right thing’ and contribute to the ‘greater good’ as well as having a sense of pride and attachment to their properties and taking pride in improving the condition of their property. Some landholders show pride in their farms and in making improvements to their properties:

*“[the growers say to me] ‘Did you see the ducks in my wetland today? It’s really cool’ you know, like little things like that, like, and ‘You know, all these trees here weren’t here before’. Or ‘You know, the river, there’s no erosion happening on the river’. They’re very proud of those things. Yeah, they can see the improvements that have happened. But that’s not what we are focused on, it’s still ‘You’re still not doing a good enough job’”.*

(Local expert 9)

An important part of the good growers approach is to ensure that effort and progress is acknowledged:

*“Just some sort of recognition where they [landholder] implement a practice change will say well you know good stuff, this is probably you know you’ve probably reduced DIN [dissolved inorganic nitrogen] losses from your property by X”*

(Local expert 1)

Acknowledging progress will help build that sense of pride and empower growers to continue on their practice change journey. Tangible markers of progress (e.g., trees planted, reduced erosion on a landholder’s property) are important and need to be related to the landholder’s property, as opposed to talking about downstream improvements. In the case of downstream water quality improvements, it can be challenging for landholders to see first-hand the progress.

The good growers approach also has important implications for landholders’ sense of connection with their growing community. The good growers approach should avoid saying that one individual grower is better than another but rather try and build unity and a collective sense of growers working together towards the greater good.

When using this approach when engaging with landholders consider the following:

- Water quality improvements can be intangible for a landholder as they occur downstream of their property and are hard to visualise. Hence, try connecting it back to something that is tangible to the landholder and something that they value, for example, if the landholder enjoys fishing then discuss improvements in fish stocks, if the landholder has a strong connection with grandchildren, then maybe connect with leaving a legacy for grandchildren.
- This approach is not about comparing landholders or implying that there are ‘bad growers’ rather it is about building a collective sense of unity, pride and empowerment among the growing community.
- Consider how to use this approach to strengthen the landholder’s connection and identity with the growing community.
- Avoid singling landholders out in a way that will make them feel ostracized from the growing community.

#### Approach 4: Hope for the Future

One aspect that came through quite strongly in the interviews is that there is a high degree of uncertainty surrounding the future of the cane industry. There is uncertainty around the longevity and sustainability of mills, instability in market conditions with rising prices of inputs (fertiliser, fuel), reducing profit margins, changing climate conditions and a landholder population that is aging with a lack of young landholders entering the industry:

*“There’re very few young people joining in at the other end, no pipeline coming through. And there’s other issues, there’s economic issues, it’s high cost, high, very high capital cost business, low returns.”*

(Local expert 10)

This uncertainty can be overwhelming and make it difficult to have capacity to take on new practice changes. It is important to be aware of this when engaging landholders on practice change and to communicate the practice change as a way of future proofing and providing stability for their farm:

*“And that was one of the big inputs that we had into the project design was about making sure that the growers are getting really good quality advice upfront and that it’s and at every single step that they are taking is future proofed. It doesn’t become obsolete because they’ve made, they make a change along the way, they need to. It needs to be part of a longer-term plan so that it all become it all comes to interplay and stays in play. The worst thing you can do is invest and then two years down the track going should spend that money on that instead.”*

(Local expert 2)

If landholders are experiencing stress and pressure from the multiple coinciding changes that are occurring within the cane industry, then it is important that the practice change isn’t seen as yet another change and complication but rather as a way for landholder to feel empowered and hopeful about the future of their farm.

When using this approach when engaging with landholders consider the following:

- Consider ways to help the landholder feel empowered and in control of their future
- Consider ways to present the practice change as helping to solve a landholder’s problems and a way for future proofing their farm, for example, linking agronomic support with climate planning for the future to address the increased weather variability/instability that is likely to be presented in the future with climate change.



**Table 4: How to apply the practice change approaches across different sugarcane landholder profiles**

	<b>Approach 1: Telling the whole story</b>	<b>Approach 2: Profitability and productivity</b>	<b>Approach 3: The good growers</b>	<b>Approach 4: Hope for the future</b>
<b>Traditionalist</b>	Work with the landholder to problem solve and simplify and break down the science into practical, on-ground demonstrations and explanations	In cases where the spouse is involved in off-farm management consider opportunities to engage them in this Approach.	In cases with older landholders or where landholders have close relationships with grandchildren consider talking about legacy and leaving a positive impact for the next generation	Most older landholders are approaching retirement, and many have children who have developed careers outside of the cane industry. Acknowledge how far they have come in their career and the importance of leaving a positive impact
	<p><i>Questions:</i></p> <p><i>What are some of the challenges you've been facing?</i></p> <p><i>How have you attempted to address these challenges?</i></p> <p><i>What different practices might you like to find out more about?</i></p>	<p><i>Questions:</i></p> <p><i>What are some of the challenges you've been facing?</i></p> <p><i>What different practices/methods would you like to find out more about?</i></p>	<p><i>Questions:</i></p> <p><i>What legacy from your land would you want to leave for future generations?</i></p> <p><i>How would you like to be remembered as a landowner?</i></p>	<p><i>Questions:</i></p> <p><i>What legacy from your land would you want to leave for future generations?</i></p> <p><i>If you could do time travel and arrive here in the year 2070, what would you like to see happening?</i></p>
<b>Lifestyle/Hobby Farmer</b>	Connect how the practice change will support the lifestyle goals of the landholder	Emphasise time saving benefits	Talk about making a positive contribution to their community	Talk about being able to maintain their lifestyle in the future through making certain changes now
	<p><i>Questions:</i></p> <p><i>What are some of the challenges you've been facing?</i></p> <p><i>How have you attempted to address these challenges?</i></p> <p><i>What would make your lifestyle more satisfying?</i></p>	<p><i>Questions:</i></p> <p><i>Apart from hobby farming what other goals do you have?</i></p> <p><i>What financial goals, if met, would help you to achieve those goals?</i></p>	<p><i>Questions:</i></p> <p><i>How would you like the community to regard you and your hobby farm?</i></p> <p><i>What kind of contribution to the community would be most satisfying?</i></p>	<p><i>Questions:</i></p> <p><i>What legacy from your land would you want to leave for the community?</i></p> <p><i>If you could do time travel and arrive here in the year 2070, what would you like to see happening?</i></p>
<b>Conservationist</b>	Connect the practice changes with the broader environmental impacts and contribution of the landholder's property to deliver ecological and downstream water quality benefits	Talk about the environmental cost savings of the practice change (e.g., reduced carbon footprint of the farm from reduced DIN application)	Highlight role of being an environmental steward and doing your part for the environment	Talk about improving the condition of their farm and contributing to a better environment. creating a better future.

	<b>Approach 1: Telling the whole story</b>	<b>Approach 2: Profitability and productivity</b>	<b>Approach 3: The good growers</b>	<b>Approach 4: Hope for the future</b>
	<p><i>Questions:</i></p> <p><i>What are some of the challenges you've been facing?</i></p> <p><i>How have you attempted to address these challenges?</i></p> <p><i>Beyond taking care of your land what positive impacts would you like to see as a result of your farming practice?</i></p>	<p><i>Questions:</i></p> <p><i>What have you done so far to reduce your carbon footprint?</i></p> <p><i>What else might you like to do in this regard?</i></p> <p><i>Have you considered any of these ideas?</i></p>	<p><i>Questions:</i></p> <p><i>What kind of contribution to other conservationists would be most rewarding for you?</i></p>	<p><i>Questions:</i></p> <p><i>What legacy from your work would you want to leave for other farmers/landowners?</i></p> <p><i>If you could do time travel and arrive here in the year 2070, what would you like to see happening?</i></p>
<b>Enterprise Farmer</b>	<p>Connect the practice change with the landholder's entire enterprise and the economies of scale and resulting benefits to the landholder</p>	<p>Talk about being an industry leader and leading best practice as well as the time saving benefits</p>	<p>Where possible support landholders in showing leadership and advocacy for practice change with their growing community</p>	<p>Focus on future proofing and creating a sustainable and viable farm where decisions made now will pay off in the long run</p>
	<p><i>Questions:</i></p> <p><i>What are some of the enterprise challenges you've been facing?</i></p> <p><i>How have you attempted to address these challenges?</i></p> <p><i>How would you like to make your enterprise more sustainable?</i></p>	<p><i>Questions:</i></p> <p><i>What financial and productivity goals do you have for your enterprise?</i></p> <p><i>What financial goals, if met, would see you regarded as leading best practice?</i></p>	<p><i>Questions:</i></p> <p><i>How would you influence other landholders in your community?</i></p> <p><i>What kind of contribution to the community would be most satisfying?</i></p>	<p><i>Questions:</i></p> <p><i>What practices now would set you up well in the long run?</i></p> <p><i>If you could do time travel and arrive here in the year 2070, what would you like to see happening?</i></p>
<b>Experimenter/Diversifier</b>	<p>Consider more innovative approaches to the practice change and how this can be integrated with the landholder's current practices</p>	<p>Talk about innovation, optimising technological advancements and efficiencies and leading best practice</p>	<p>Where possible support landholders in showing leadership and advocacy for practice change with their growing community</p>	<p>Focus on future proofing and creating a sustainable and viable farm where decisions made now will pay off in the long run</p>
	<p><i>Questions:</i></p> <p><i>What kinds of ideas or innovations have you been exploring?</i></p>	<p><i>Questions:</i></p> <p><i>What return on investment are you looking for?</i></p>	<p><i>Questions:</i></p> <p><i>How would you like your peers to regard you and your farming practice?</i></p>	<p><i>Questions:</i></p> <p><i>What legacy from your land would you want to leave for future generations?</i></p>

	<b>Approach 1: Telling the whole story</b>	<b>Approach 2: Profitability and productivity</b>	<b>Approach 3: The good growers</b>	<b>Approach 4: Hope for the future</b>
	<i>What have you learned from your attempts so far?</i>	<i>What would an even more productive farm look like for you?</i>	<i>What kind of influence would you like to have?</i>	<i>If you could do time travel and arrive here in the year 2070, what would you like to see happening?</i>
<b>Benefits of using this approach</b>	Acknowledges the landholder's goals for their farm and integrates practice change with these goals as opposed to 'adding on'	Acknowledges the business aspect of managing a farm and frames clear tangible benefits on cost and time savings	Acknowledges landholder progress and taps into more innate and value-based motivations for practice change	Acknowledges the uncertainty in the cane industry and builds sense of empowerment and hope for landholders
<b>Limitations to using the approach</b>	Can require a somewhat advanced level of technical expertise, experience and understanding which may be challenging for early career extension officers.	Market conditions will change (for example, if the cost of urea drops) which can make it difficult to demonstrate cost saving. Multiple factors affect productivity which again can make it difficult to demonstrate that reduced DIN won't reduce productivity.	Will have to be very aware of the social norms of the growing community and make sure that this approach builds a collective sense of being a good grower instead of an individual sense.	There are a lot of unknowns about the future of the cane industry and providing meaningful hope or futureproofing can be challenging

## 5 Conclusion

This work has provided further quantitative evidence supporting the existence of distinct profiles within the sugarcane farming communities. However, interviews reveal that not one size fits all when engaging with landholders, regardless of which profile that landholder might most strongly identify with. Using a systems-thinking approach, we analysed the qualitative data to identify the different factors that shape practice change across different system levels. This builds a valuable understanding on the social system of practice change in the cane growing sector. Informed by this social context, we developed practice change approaches to support effective engagement of landholders in practice change.

Further work needs to be done to test and refine these engagement approaches with extension officers in the field. An appropriate next step would be to test the engagement approaches with extension officer focus groups and develop the appropriate tools and resources (e.g., information sheets, online tools) that are fit-for-purpose and practical for extension officers to apply and refine the findings of this research in the field. Similarly, this research has identified multiple system level factors (e.g., landholder relationships with peers, extension officers and family) and individual level factors (e.g., age, education level, digital literacy, personal values, attitudes and goals) that can influence landholders' capacity and willingness for practice change. These factors should be considered and where appropriate information on these factors should be gathered, for example, through inclusion of value and attitude questions in landholder surveys or through other research approaches such as social network analysis of landholder networks.

## 6 Limitations

There are several limitations associated with the qualitative and quantitative data used in this report.

Quantitative data limitations:

- **Small sample size:** A small sample size reduces the power of the research and increases the margin of error. It potentially prevents this research from properly estimating and modelling the true population of Queensland reef sugarcane landholders from which we have sampled from. Although, it is important to note that the intent of this analysis is aimed less at providing definitive typology characterisations, and more towards the development of a proof-of-concept technique for characterising Reef sugarcane landholders into their appropriate landholder types.
- **Incomplete dataset:** After a desktop review and data audit, the Future of Farming survey was chosen as the most appropriate data set for this research. One of the key reasons the Future of Farming survey was chosen was because the dataset most comprehensively covers the identified indicators in determining landholder types, compared to other datasets. However, it is important to note that although the Future of Farming survey provided the most comprehensive option for capturing data across the various indicators, the survey did not cover them all. The survey did not provide data on the 'trust for government' indicator which was determined to be a potential indicator in the previous work. Future research could seek to include data on the 'trust for government' indicator, as well as other indicators beyond those used in this analysis.
- **K-means clustering is subject to interpretation:** Although K-means clustering provides K-means scores (mean, min, max), it is up to the researcher to derive meaning from and interpret these results. The possibility exists for the researcher to interpret the outputs of K-means clustering incorrectly, or for different researchers looking at the same results from K-means clustering to arrive at different qualitative outcomes. Schwarz et al (2009), for example, decided not to label their typology in order to avoid value-judgements being made about each emergent style.
- **K-means clustering – technical limitations:** Like many quantitative techniques, K-means clustering comes with its own unique set of technical limitations. For example, it has been observed by several researchers that when a dataset contains outliers there will be a variation in the result that means no stable result from different executions on the same data. Outliers can increase the sum of squared error within clusters (Shukla & Naganna, 2014), however this was not identified as an issue in our data.<sup>6</sup> Other technical limitations of K-mean clustering include empty clusters and non-globular cluster shapes and sizes, see Shukla and Naganna (2014) for further information. The potential for these analytical limitations should be taken into consideration in future studies.
- **Mutual exclusivity of clusters:** The K-means clustering approach identifies mutually exclusive clusters in the data. It should be acknowledged that in reality farmer types are not necessarily mutually exclusive. There may be overlaps between groups which are not captured in this approach.

Qualitative data limitations:

- **Sample representativeness:** Care was taken to select interviewees that represented different perspectives as well as different regions. However, the perspectives gathered are those of delivery providers, some who were themselves extension officers, and hence may have a certain view on particular factors. While we didn't include

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<sup>6</sup> Using the interquartile range method, an assessment of outliers was undertaken for the included variables. There were no outliers of significance, except in the case of the farm size variable (noting that most variables were either binary or Likert scale measures and therefore were constrained to a specific range of responses). The farm size responses that were above the threshold were still feasible farm sizes and all ended up being clustered together in the enterprise farmer group.

the perspectives of individual landholders, the purpose of this data collection was to gain an understanding of the social system as a whole as opposed to individual landholder perspectives. Hence, the selection of the interview participants was deemed appropriate for addressing our research aim. That said, we recommend that future research further tests the findings of this research through testing our proposed engagement approaches with landholders or holding focus groups with industry representatives.

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# Appendix A: Interview Guide

## Local Expert Interview Guide

Possible interview questions include:

- What types of landholders do you work with?
- What do you think are some of the commonalities or unique differences between these different types of landholders?
- Are there any characteristics of these landholders that you think make it easier or more difficult for those landholders to engage in your program?
- Can you please tell us about some of the strategies you use to engage landholders in your program?
- With the types of engagement strategies you use, do you tailor these based on the type of landholder you are working with? If so, how do you tailor the engagement?
- What do you find works well when engaging with landholders?
- What do you find doesn't work well when engaging with landholders?
- What kinds of landholders do you find difficult to engage with?
- Is there anything else we should know about how to engage with different types of landholders?