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Technical Report

Factors affecting adoption of land management practices
that have water quality benefits: Evaluation of scenarios
for cane farming in GBR catchments
RRRD010



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Factors affecting adoption of land management practices that have water quality benefits: Evaluation of scenarios for cane farming in GBR catchments (Project RRRD010)

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Acronyms & Abbreviations

BMRG	Burnett Mary Regional Group
BSES	Bureau of Sugar Experiment Stations
CQU	Central Queensland University
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DoE	Department of the Environment
GBR	Great Barrier Reef
GBRMPA	Great Barrier Reef Marine Park Authority
MAPS	Mackay Area Productivity Services
NRM	Natural Resource Management
RRRC	Reef and Rainforest Research Centre Limited
RRRD	Reef Rescue Research & Development
SRDC	Sugar Research and Development Corporation
LMP(s)	Land Management Practice(s)

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Executive Summary

The aim of this study was to identify factors affecting adoption of land management practices (LMPs) in cane farming that have water quality benefits in Great Barrier Reef (GBR) catchments. The project used a case study approach to explore the key factors that affect adoption of LMPs in two regions of the GBR catchment – Mackay and Bundaberg. A literature review identified factors that impact on the adoption of LMPs in cane farming, and these were examined in greater detail through discussions with 17 stakeholders and 116 cane farmers. Their responses were then analysed through descriptive statistics, fuzzy logic and a measure of consensus and agreement¹.

This study assessed the acceptance by cane farmers of three categories of land management practices in cane farming in GBR catchments, Queensland: (1) nutrient and herbicide management, (2) soil and erosion management, and (3) water and irrigation management. The study found that cane farmers are most interested in nutrient and herbicide management practices (with an average 70% consensus and agreement), compared to soil and erosion management, and water and irrigation management practices (with an average 50% to 60% consensus and agreement).

Within all three categories of land management, the following practices were considered the most desirable and relevant LMPs with water quality benefits, specifically at the paddock scale:

- green cane trash blanket retention,
- grassed headlands,
- drains and swails,
- sediment traps and contour banks,
- irrigation scheduling based on block and soil types,
- timing nutrient and pesticides application with regard to crop stage,
- irrigation scheduling that takes into account rainfall patterns,
- soil testing fallow blocks each year, and
- variable rate of fertilizer/pesticides application between blocks and application rates based on latest industry recommendations.

The study also examined the factors influencing adoption of LMPs that have water quality benefits and provided a summary of these factors. The survey results identified nine factors that appear to have the greatest influence farmers' decisions to adopt changed practices:

- access to and availability of cash flow,
- working full-time on the farm,
- self-desire to protect natural resources,
- self-awareness and openness to current and scientific knowledge,
- focus on controlling own practice,
- maintaining a quarterly budget,

¹ Consensus is a measure of collective opinion of a group, while agreement is a measure of a harmony of opinion or action.

- having a cost control and risk management plan,
- capacity to maximise profit and minimise labour and overhead costs,
- maintaining a long-term steady profit, and
- long-term involvement with farming.

Half of these factors are economic factors and half of these are socio-cultural factors. This demonstrates how socio-cultural and economic factors significantly influence farmers in making decisions about the adoption of LMPs, and a sophisticated understanding of social, economic and cultural dynamics is critical for increasing adoption of LMPs in cane farming that have water quality benefits.

The study concluded that decisions about the adoption of LMPs with water quality benefits are equally dependent upon four categories of factors:

- socio-demographic,
- cultural,
- economic, and
- support services.

There are also linkages and barriers among the factors influencing the adoption of LMPs with water quality benefits. Further study of linear and non-linear linkages between social, political and institutional systems that influence the adoption of LMPs with water quality benefits is needed. An in-depth qualitative study on the effectiveness of support services is also necessary as support services are very important in determining and influencing LMP adoption decisions.

1. Introduction

Land use in Australia since European settlement reflects expansion patterns that were shaped by climate, geography, knowledge, technology and opportunity. Initially, land management practices in Australia were developed by trial and error as localised knowledge of climate and seasonal variability developed. Since the 1950s a secondary phase of agricultural expansion has occurred, which was shaped by developing world agricultural markets and the lessons of scientific research into the problems of 'traditional' agriculture (Laut, 1988). Concerns surrounding the sustainability of some agricultural land management practices entered the public debate during this period and sensitised agricultural researchers and practitioners to consider the ramifications of agricultural practices on other land uses.

According to the Australian Government State of the Environment report the dominant agricultural land use in Australia has been livestock grazing of native vegetation (46%) and the grazing of modified pastures (9%) with conservation or minimal use of native vegetation accounting for 36% of land use (Australian Government, 2009). Irrigated and intensive agriculture consumes approximately 0.6% of Australian land, however its impact on the natural environment has been arguably disproportionate to the relative land area utilised.

In the Great Barrier Reef (GBR) catchment, agricultural land management practices (LMPs) associated with irrigated and intensive agriculture have been linked with a number of unsustainable processes including a reduction in biodiversity, degradation of ecosystem services, and degrading soils and waterways (Williamson et al. 2009). One of the dominant land uses in the GBR catchment is sugar cane farming and farmers typically use various types and amounts of nutrients and pesticide on their crops as well as various soil and water management practices, which have attracted close evaluation (Brodie et al. 2012).

According to the Reef Plan GBR Report Card (State of Queensland, 2011), pollutant discharge to the Reef has increased with sediment loads (up between 300% and 900%), phosphorus (up between 300% and 1,500%), nitrogen (up between 200% and 400%) and pesticide residues all higher since European settlement in the region. About 10 million hectares of land are under agricultural use (i.e. sugarcane, horticulture, grazing and cotton) in GBR catchments (Mackenzie et al. 2004). The majority of irrigated land in the GBR catchment is devoted to sugarcane and therefore its LMPs can potentially have substantial impacts on surrounding waterways and the Reef. This study aims to explore specific LMPs associated with sugar cane production that have water quality benefits at the paddock level within the GBR region and the factors affecting adoption of such LMPs.

The project specifically addresses Reef Rescue Research Priorities 4.3 (socio-economic effects of implementing improved land management practices) and 4.4 (adoption of improved land management practices across Reef catchment). The results have been directly informed by government(s), cane farmers and stakeholders in relation to key factors that affect the adoption of LMPs. In particular, based on the assessment of the adoption of LMPs in cane farming, a number of strategic guidelines are presented at the end of this report, for future improvement or enhancement of current practices that can bring water quality benefits in the GBR ecosystem.

This introduction forms Section One of this report followed by a literature review in Section Two on land management practices that have water quality benefits in general, LMPs for cane farming in particular, and the factors affecting adoption of such practices. Section Three outlines the project objectives and Section Four describes the research methods that were used to identify and examine the factors affecting adoption of LMPs that have water quality benefits. This is followed in Section Five by a description of the study area. Section Six presents the findings of this study followed by a discussion in Section Seven. Section Eight highlights the benefits and application of the project findings. Section Nine provides some conclusions and interprets the project findings, followed by some future directions in Section Ten.

2. A review of characteristics and factors of LMPs

The adoption of LMPs that have a water quality benefit for the GBR region in addition to improving the sustainability of agricultural enterprise is highly desirable from the ecological and economic perspectives (Drewry et al. 2009). The challenge however is to best understand the factors that determine the adoption of appropriate LMPs those are preferable to agricultural stakeholders and practitioners and farmers (end users).

Land management responses to address the concerns of biophysical degradation within the GBR catchment areas were the focus of the National Water Quality Management Strategy and the Queensland Environmental Protection (Water) Policy 1997 and 2009, and have developed into a targeted response, the Reef Water Quality Protection Plan (Reef Plan). The Reef Plan has concentrated on the introduction of on-ground land management practices that have been supported by substantial evidence, including trials, to have beneficial outcomes for water quality. These include riparian protection measures, increased cattle movement protection, machinery modifications, fertilizer and chemical controls, and changed cultivation and harvesting practices. The Reef Plan has introduced targets for improved practices and biophysical outcomes as well as the targeting of specific 'hotspot' locations in the GBR (Brodie et al. 2012).

A number of studies have been undertaken, to date, to identify those land management practices that may improve water quality at paddock level (Brodie et al. 2012; Wilkinson and Brodie, 2011; ACLUMP, 2010; DPIF, 2009; Drewry et al. 2008; Keipert et al. 2008; Rolfe et al. 2008; Smith, 2008; Thornburn et al. 2007; SRDC, 2007; Eldridge, 2004; LRAM, 2004; Caryet et al. 2002; Stewart, 2001) that ultimately impact the water quality in the GBR region include: soil structure and fertility management, sediment and erosion management, nitrogen management, nutrient management, chemical management, riparian zone management, and irrigation management. Schroeder et al (2008) explored few land management practices at paddock level within the GBR catchments and they found green cane trash blanketing, adoption of improved cropping system based on reduced tillage, controlled traffic and legume break crops, soil specific nutrient management and riparian vegetation were the most effective practices that can reduce soil, chemical and nutrient runoff from the paddock to the reef. Considering the outcome of these studies as well as further discussion with some stakeholders and the cane farmers within the Bundaberg and Mackay region, this study grouped all LMPs into three main groups: soil and erosion management, water and irrigation management, and nutrient and herbicide management.

However within these categories of LMPs in cane farming that have the potential to improve water quality have been classified through the WQIP process, involving extensive consultation and workshopping with technical experts and land managers as A, B, C and D practices, where A is the most desirable practice and D is low standard practice (Drewry et al. 2008; DPIF, 2009). The ABCD framework of land management practices is a scalable planning tool and a useful means of communicating about a set of practices on the basis of their potential to offer improvements to water quality. In simple terms the framework is:

- Class A – Cutting edge practices – may require further validation of costs and benefits,
- Class B – Best management practices (BMPs) – acceptable in medium term,
- Class C – Common practices – ‘Code of practice’ – may not be acceptable in medium term, and
- Class D – Old practices – not acceptable by current standards.

While targets for changed LMPs have been set within the WQIP there is limited information available on the current adoption rates within the cane industry in the Mackay and Bundaberg regions. This research will assist in providing better information on the take-up of the targeted LMPs within the Mackay and Bundaberg regions. The adoption rate estimates based on data from the 2007/08 workshops showed that an increase of A and B class practices and a corresponding decrease in C and D class practices. These estimated a 15% adoption of A and B practices with a target set for 2014 of 80 % (Drewry et al. 2008).

The GBR Report Card 2011 presents the scale of the challenge in changing LMPs to improve reef water quality. Optimistically the report card shows some important improvements in the adoption of improved land management practices; however the results are not uniform across the six main catchments that feed into the GBR. For example, the proportion of sugarcane growers who have adopted improved LMPs between 2009 and 2011 ranges from 28% (Burdekin) to 42% in the Burnett Mary region. The average adoption rate by sugarcane growers across the GBR region was 34 % against the ambitious target set by the Reef Plan is 80% by 2013 (State of Queensland, 2011).

Category ‘B’ LMPs have been identified as having significant benefits in maintaining good water quality at paddock level (Drewry et al. 2008) and DPIF (2009) also referred these LMPs of cane farming as ‘Best Management Practices’. Therefore this study deals with adoption of the category ‘B’ LMPs for cane farming within the GBR catchments.

A key concern of the research is potential drivers or constraints that influence adoption of LMPs that have water quality benefits. It is noted that there are two main aspects that inform adoption decisions and these are acquiring the prerequisite knowledge of new innovations, and developing the necessary skills to implement the new practices satisfactorily (Ghadim and Pannell, 1999; Tsur et al. 1990). Guerin (2000) found different factors for different types of farming such as sugarcane, horticulture, cropping and grazing and he organised these into three broad categories: first land user’s characteristics such as personality, education level and the degree of motivation; the second is the LMP(s) itself i.e., user-friendliness and cost effectiveness; and the third is the role of the extensions agents, trials and adoption processes. Schroeder et al. (2008) found awareness of impacts of

nutrients and pesticides among the farmers and the farmers' attendance to the workshops and training session were important factors that can influence the adoption of LMPs that have water quality benefits.

In addition, the factors influencing the adoption of LMPs can be constrained by poor or low financial viability (Cary et al. 2002) as this has been shown to be a strong factor in previous research (Cary et al. 2002; Lockie and Rockloff, 2004; Byron et al. 2004). While much of this research relied on the 'self-reporting' of financial viability, Cary et al (2002) contends that farmers perceptions of future financial viability is an important factor in the decision making process and a better predictor of adoption than objective accounts of financial viability. Further Stanley and Clouston (2005) highlighted that the interconnectedness of economic, historic, cultural and social factors that overlay the biophysical in influencing decision making over LMPs.

Some of the key findings from Stanley and Clouston (2005) (See also Bates et al. 2009):

- Limited evidence supporting a link between formal education and adoption rates;
- Post formal education seems to increase adoption (Cary et al. 2002);
- Age of the farmer does not appear to influence adoption rates (Lockie et al. 2002);
- Stewardship attitude by farmers does not necessarily override the need for short term productivity (Lockie and Rockloff, 2004);
- Differing time frames do seem to impact on farmers decision making regarding longer term preservation practices;
- Local community influence appears a consistent factor;
- Succession planning indicates long term planning but not necessarily adoption of new practices (Gray et al. 2000; Taylor et al. 2000; Guerin and Guerin, 1994)
- Reluctance to accept at face value scientific advice appears to be a constraint to adoption rates (Lockie and Rockloff, 2004)
- Contextualisation of LMP problems for farmers can increase the commitment to better practices (Richards et al. 2003)
- Profitability is a key factor;
- Compatibility with existing practices and the ease of adoption also seem to affect uptake of new practices; and
- Support for trials of new practices and for farmers to witness the practice and to see the possible benefits based on substantive evidence (Byron, 2005).

External factors, including the provision of incentives and the removal of regulatory barriers, have also been considered. Four strategies for accelerating the adoption of beneficial LMPs (Class A and B) suggested in the Water Quality Improvement Plan (2008) were:

- Industry leadership,
- Knowledge support,
- Financial support, and
- Decision support.

The focus on specific LMPs that potentially have a high likelihood of uptake with farmers is a sensible goal and a focus of this research. Researchers have argued that adoption of LMP tends to be based on subjective rather objective perceptions of the possibility that practices will assist farmers to meet their specific goals and this viewpoint guides the methodologies

adopted in the research (Pannell et al. 2006). Therefore assisting in the prioritisation of LMP and increasing the knowledge bank regarding the adoption of specific LMPs as identified by Brodie et al. (2012) is one of the important steps required to meet the Reef Plan targets for the reduction in pollutants in the GBR. Halkos and Jones (2012), Ecker et al. (2011), Jakku and Thornburn (2010), Shiferaw et al. (2009), Finlay et al. (2005), Stanley et al. (2005), Tenge et al. (2004) and Lefray et al. (2000) also suggested multiple factors such as social, cultural, economic, technical and institutional (support services) and political, however among all these studies, only Jakku and Thornburn (2010) highlighted the political factor in national context that can affect the adoption of LMPs to the farmer. Hence this study has grouped all factors except biophysical factors into four categories: socio-demographic, cultural, economic, and support services (Table 1).

Firstly, these factors were discussed informally with the stakeholders, key researchers and cane farmers within the Bundaberg and Mackay regions in order to identify which factors are less important to cane farmers in each region. Secondly, stakeholder and farmers were asked through a structured questionnaire about the importance of these factors in making adoption decisions. A brief methodology for testing these factors at the paddock scale has been outlined in the Methods Section.

3. Project objectives

Although the impacts of cane farming LMPs on the environment in GBR catchments depend on a multitude of factors such as the prevailing climatic conditions, the biophysical make-up of the land, and previous farming practices, this project aims to improve our understanding of the social, economic and cultural factors involved with the adoption of LMPs. To achieve this aim and to guide the analyses process, a tool has been developed to capture farmer's preferences and stakeholder perceptions towards key factors affecting adoption of LMPs that have water quality benefits.

The objectives of this project are to:

1. Explore the characteristics of LMPs within cane farming that have water quality benefits in GBR catchments.
2. Identify key factors affecting adoption of LMPs.
3. Develop a decision support tool to identify key indicators that can describe the nature of adoption and performance of each factor.
4. Provide results-based strategic directions to improve LMPs in cane farming that have water quality benefits in GBR catchments.

Table 1 Factors affecting the adoption of LMPs

Socio-demographic	Cultural	Economic	Support services
Farmer's age, gender and education	Desire to protect natural resources	Cost (status quo)	Support from the farmers group
Household size and family situation	Desire to improve amenity of the landscape	Increased input costs	NRM/BSES facilitators
Family involvement in farming	Keeping and updating farm plan	Return (profitability – short and long term)	Support from the Sugar Mills
Non-family member's involvement in farming	Local knowledge versus scientific knowledge	Farm/Land value (increase or decrease)	Support from the Local Government
Farm ownership	Time management	Availability of funds/financial constraints	Support from the State Government
Farm's owner attitude towards adoption of LMPs	Awareness of new LMPs	Financial incentives	Support from the Federal Government
Length (year) of involvement with cane farming	Openness to new LMPs	Taxes and levies	Support from the private consultants
Farm size	Recognition by neighbours and community/ peer influence and encouragement from success	Alternative farming/land use in adverse climatic condition	Peers and neighbours' support
Multiple land use	Fit in with practice of others in my community	Market failure	Own capacity to manage the farm
Work pattern (full-time, part-time, hobby farming)	Focus on controlling own practice/learning by doing	Income risk	Demonstrations and trials of new LMPs
Off-farm income	Family influence		Information provision and training including risk and new LMPs
Role of succession (plan to pass farm on to the next generation)	Lifestyle choice		
Plan to leave this occupation for good	Social prestige		
Intend to expand or decrease the farm size	Changing social norms		
Aversion to risk/risk neutral/ risk management for short term losses	Beliefs and values		
Community connectedness			
Confidence of the future viability of cane farming			

Source: Brodie et al. 2012; Greer et al. 2012; Halkos and Jones, 2012; Ecker et al. 2011; Jakku and Thorburn, 2010; Shiferaw et al. 2009; Finlay et al. 2005; Stanley et al. 2005; Byron et al. 2004; Lockie and Rockloff, 2004; Tenge et al. 2004; Cary et al. 2002; Dunn et al. 2000; Gray et al. 2000; Lefray et al. 2000; and Phillips, 2000.

4. Methods

Theoretical underpinnings and research design:

Besides the economic theories and models, a number of behavioural theories (Hoffman, 2006; Rogers, 2003; Ajzen, 1991) have been developed in order to understand adoption decision because of limited ability of economic models to explain decision and to capture complexity of farmers' attitudes and behaviour (Ndah et al. 2010, Hoffmann, 2006). Rogers (2003) described adoption as a basic level of behavioural utilization, while Ajzen (1991) described adoption as a planned behaviour and Hoffman (2006) describes adoption through diffusion.

Any person wants to behave rationally as per given information and knowledge as well as the circumstances through the dynamic interactions between the human and the environment. Human being sometimes perceived subjectively based on his or her worthiness of adoption and most time, they try to avoid the negative or undesirable situation. Therefore cultural capital and availability of information are playing important rules compared to economic incentives models because economic models of adoption may work promptly but cannot last for a long period of time, is not suitable and also cannot capture the human social and cultural behaviour. Along with exploring aforementioned four categories of factors affecting adoption of LMPs in cane farming, this study will test whether the economic and socio-cultural attributes are differently affecting the adoption of LMPs.

Based on the literature review on LMPs and the factors affecting adoption of LMPs and also based on the above mentioned behavioural theories, the following figure draw the research-design framework for this study.

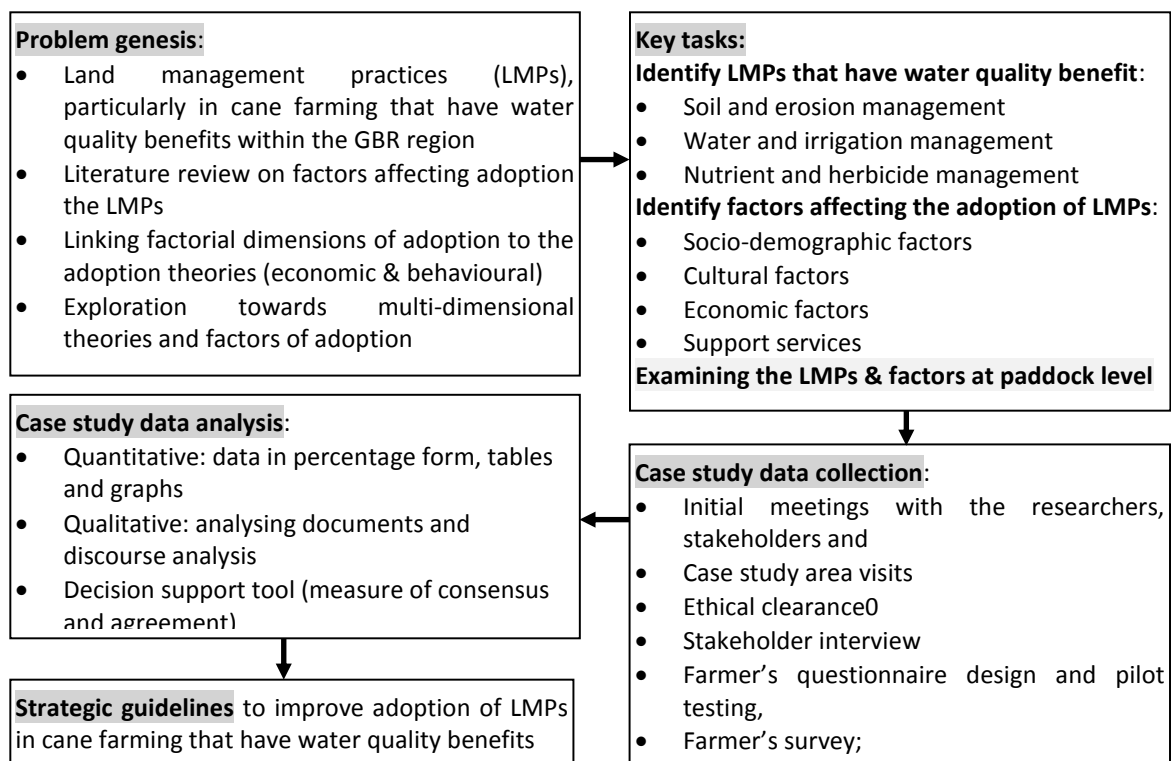


Figure 1 Structure of the research methodology

Research approach:

Previous research into the selection and prioritisation of LMPs has been conducted using a variety of research methods drawn from the social sciences primarily in order to attempt to understand the complexity of decision-making processes around LMPs (Brodie et al. 2012). Consideration has been given to these past methods in designing this research (Figures 1 and 2). This study utilised a mixed methods research approach, which used a combination of quantitative and qualitative data, to explore the complexity of LMPs' adoption². The mixed method approach involved consultation and engagement with the research community to develop expert knowledge to facilitate the substantive evidence gathering to support the analysis and deliberation phases of the research.

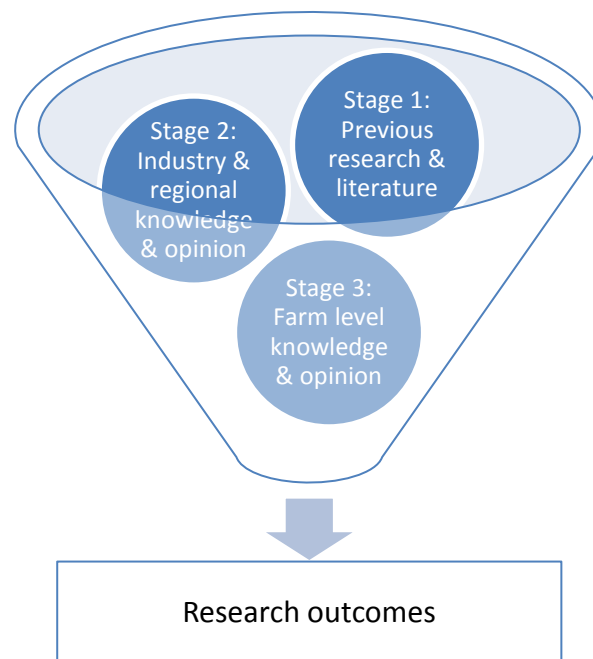


Figure 2 Research Flowchart

Drawing on previous research and literature (stage 1) in the area of LMPs in GBR catchments and knowledge regarding adoption factors of LMPs, the research team proceeded through a two-stage process of data collection.

The study adopted a collaborative approach to first engage with key stakeholders (stage 2) to determine the level of agreement with factors that were grouped into four dimensions, namely socio-demographic, cultural, economic, and support services.

This process allowed for refinement of a survey of cane farmers (stage 3) to gauge the level of consensus and agreement for specific LMPs and to ascertain the factors impacting on the farmer's decision for adoption of LMPs.

² Ethical approval (CQUniversity H12/06-128)

The data was analysed and the subsequent conclusion evaluated against previous research in order to develop a set of clear recommendations to enhance the adoption of LMPs and to assist in reaching the Reef Plan targets for Class A and B LMPs.

The study used fuzzy logic methods to develop a consensus³ and agreement measurement of quantitative data combined with analysis of qualitative data to identify the most important factors influencing the LMPs of cane farmers as well as the most relevant LMPs that have water quality benefits within the GBR. Consensus in the form of agreement over the variables and factors utilised in the measure of LMP adoption rates and the factors influencing adaptation of LMPs by farmers, as well as consensus and agreement as a statistical method to evaluate the results from stakeholders and farmers' engagements.

Sources of data and data collection:

The study used primary and secondary sources of data. The primary data collection was formally conducted between 11 August and 30 October 2012.

This study utilised secondary data such as published literature to review the current LMPs in the Mackay and the Bundaberg region. Previous research on land management practices at the farm and catchment levels was reviewed along with government policy and technical reports. This formed a sound basis to move onto the second stage of the data collection.

The study conducted stakeholder discussions to better understand their perceptions about the factors and performance of LMP adoption in cane farming and GBR water quality issues. The stakeholder responses were obtained through a two stage process in which the key factors affecting the adoption of LMPs were grouped into four main categories of: socio-demographic, cultural, economic, and support factors. An initial exploration which involved in-depth discussion of the four factors and key variables that might influence decision making relevant to the research was undertaken with four field level stakeholders (two each from Mackay and the Bundaberg regions). Following this process a selection of indicators was chosen for further examination by the remaining stakeholder participants.

The study team contacted approximately fifty stakeholders by phone and email from the sugar-cane industry within the Mackay-Whitsunday and Bundaberg regional areas. Seventeen stakeholders agreed to participate in the interviews to assess the factors affecting adoption of LMPs in cane farming. This represented a 34 % response rate.

The stakeholders were directly involved with servicing the sugar cane industry. Participants included natural resource management personnel and personnel from Canegrowers, Bureau of Sugar Experiment Station (BSES), Sugar Research and Development Corporation (SRDC) and Mackay Area Productivity Services. A majority (70.5%, n=12) of the stakeholders were directly providing support services to sugar cane farmers through either grower organisations, regional NRM groups or extension services while 29.5% (n=5) of participants were engaged with research and development for the sugar cane sector (Table 1).

³ See: Tastle and Wierman, 2007

On average the stakeholders (n=17) had been providing support services or research and development for 9.3 years and the majority of them had been working in the sugar cane sector for approximately seven years.

Table 2 Stakeholders' organizations and their involvement

Type of organisation	% of the total participation
Canegrowers Associations	23.5
Cane extension services organisations	23.5
Regional NRM Groups	23.5
Research & Development Organisation	29.5
Total (n=17)	100.0

Primary data was also sourced through 112 interviews conducted with cane farmers in the Mackay and Bundaberg regions in Queensland. All of the participants were either owners or managers or working full-time on a farm that produced sugar cane.

Participants were randomly selected from a list of cane farmers within the Bundaberg and Mackay regions that were either sourced online or supplied by the Reef catchments and BMRG's Reef Rescue Program. A total 112 interviews were conducted from a list of possible participants of 550. This resulted in a 20% response rate. Out of 112 participants, 65 from Mackay and 14 from Bundaberg were interviewed by telephone. An additional 37 interviews in the Bundaberg region were undertaken in person by CEM research staff.

The stakeholder and canefarmer interviews consisted of structured, semi-structured and open ended questions about the factors, indicators and acceptability of selected LMPs that are associated with water quality benefits for the GBR region.

Data analysis method:

Data drawn from the literature review and from qualitative aspects of stage two and three were thematically analysed on the basis of identification of key issues regarding LMPs and the understanding of new innovation adoption by farmers.

The quantitative data collected via the stakeholder and farmer surveys were initially analysed using a standard statistical package (SPSS V20) to obtain frequencies and distributions. The primary LMPs and factors affecting adoption of LMPs were analysed by more advanced statistical measures to obtain consensus and agreement values. These were obtained by using fuzzy logic based multi-objective decision methods to determine the value of each factor based on the primary quantitative data. This is a more accurate method to value ordinal data. For example, key data items for stage 1 and 2 of the study were collected using an ordinal scale, (1 to 5 where 1=not at all important, 2=somewhat important, 3=moderately important, 4=very important and 5=extremely important) to capture stakeholders and farmers preferences. The ordinal scale actually conveys a sense of approximate ordering. The categories are themselves the values; however relying on a simple measure of central tendency within a likert scale diminishes the values attributed to the data variable from all of the respondents. Issues such as bi-modal results and skewed data affect the accuracy of the results and misinform researchers.

To overcome this methodological gap, Zadeh (1965) introduced fuzzy theory, which was based on the logic of approximate reasoning as opposed to exact. Fuzzy logic is a means to calculate the categories of the likert scale and the values between the categories in order to produce a value based on a 'degree of truth' as opposed to a true or false (0-1 boolean) value. Fuzzy logic offers a more accurate way of calculating aggregated data that resembles approximate rather than fixed reasoning.

Fuzzy numbers are defined as the set of numbers which include the connection of the single value with other possible values meaning that each value has its own particular weighting. This is referred to as a degree of membership (equation 1) for each value. The theory allows mathematical operators and programming in its application and subsequently a refinement on the measurement of perceived values and opinions. The mathematical concept in this study is borrowed from Chang's Fuzzy Analytic Hierarchy Process (1996).

A triangular fuzzy number (TFN) $\tilde{A}$ on R is a special fuzzy set $F = (x, \mu_F(x))$, $x \in R$, where its membership function $\mu_{\tilde{A}}(x): R \rightarrow [0, 1]$ is equal to Eq. 1:

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < l \\ (x-l)/(m-l), & l \leq x \leq m \\ (u-x)/(u-m), & m \leq x \leq u \\ 0, & x > u \end{cases} \quad \text{---(1)}$$

From Eq. 1, l and u mean the lower and upper bounds of the fuzzy number $\tilde{A}$, and m is the modal value for A . The TFN can be denoted by $\tilde{A} = (l, m, u)$.

First all importance ratings of 5,4,3,2, 1 are converted to TFNs, $\tilde{t} = (l, m, u)$

$\tilde{1} = (1,1,2)$, $\tilde{2} = (1,2,3)$, $\tilde{3} = (2,3,4)$, $\tilde{4} = (3,4,5)$, $\tilde{5} = (4,5,5)$.

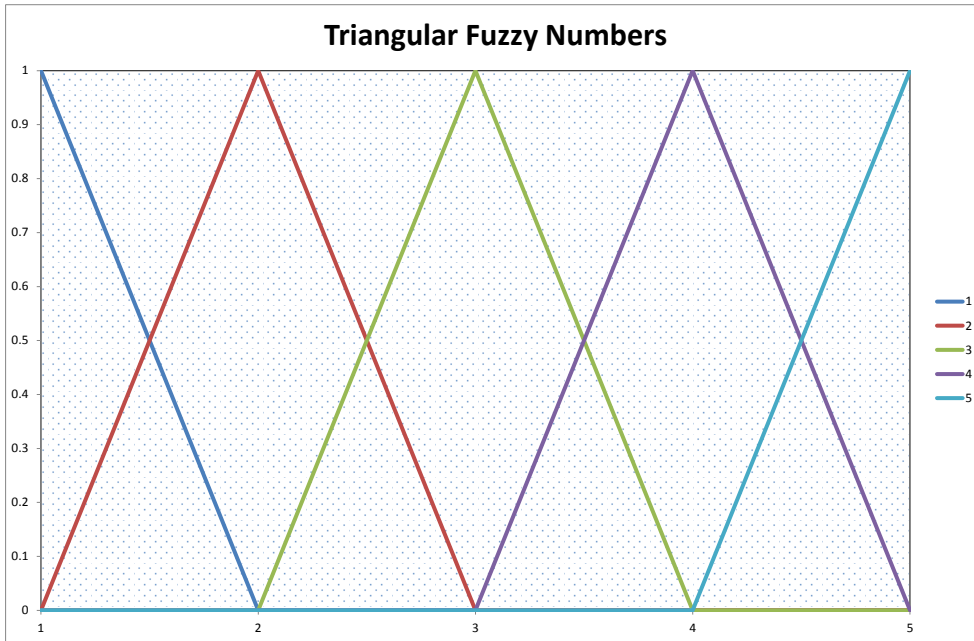


Figure 3 Distribution of triangular fuzzy number

TFNs are then 'defuzzified' by calculating the centroid and the graded mean of TFN (l,m,u), centroid = (l+m+u)/3, graded mean = (l+4m+u)/6 (Hassal, 1999). All TFNs are aggregated by consensus and agreement with the highest rank measures.

Fuzzy logic allows for the calculation of consensus and agreement measures. Consensus, in this instance, being a measure to estimate the average dispersion among the responses to a survey variable (Tastle and Weirman, 2007). Consensus is a general agreement among the members of a given group or community. Szmidt and Kacprzyk (2003) provide an interpretation of consensus in which they define complete disagreement as equal to zero and complete agreement as equal to one (cited in Tastle and Weirman, 2007). They support the argument that the consensus measure derived through the use of fuzzy logic is more reflective of a group's intentions than using the mean value of a likert scale and a simple measure of variance from the mean (Tastle and Weirman, 2007).

A consensus measure has the following components; it is determined by degrees, has a level of inferred preference, a level of alternative preference, and a level of the relationship between the components (Herrera et al. 1996). Tcha et al. (2002) (cited in Tastle and Weirman, 2007) used the following equation in to calculate the value of the interval that represents a key component of the measure of consensus. Unlike other measures that need to be normalized, this measure is always in the interval between 0 to 1.

$$\text{Consensus} = 1 - \frac{\sum p_i * \ln(p_i)}{n * 1/n * \ln(1/n)} \text{-----}(2)$$

where p is the probability associated with the distribution under consideration, i is an index, and n is the number of categories.

The consensus measure can be viewed as a "collective opinion of a group" that specifically incorporates the variation of views that are likely to exist with the individual members of the group. Tastle and Wierman (2007) have further refined the above consensus equation by adopting a proximity to consensus (equation 3).

$$\text{Cns}(x) = 1 + \sum_{i=1}^n p_i \log_2 \left(1 - \frac{|x_i - \mu_x|}{d_x} \right) \text{-----}(3)$$

$$\mu_x = \frac{1}{n} \sum_{i=1}^n x_i, d_x = x_{\max} - x_{\min} = 4 \text{ (here)}, p_i = \frac{f_i}{n}.$$

Further this study used an agreement measurement based on Tastle and Weirman (2008) definition of agreement as a 'harmony of opinion' or action. Tastle and Weirman (2008) argue that to attain a satisfactory harmony of opinion does not require that all involved individuals express the same view. For example, one might take the view that global warming is an established fact, while another might view it as an interesting factoid that is yet to be proven. Neither individual may be willing to take the view of the other, but they both might take some 'degree of ownership' in any of the preference categories if they were presented for consideration. Hence, there could be a 'harmony of opinion' in a middle category but much less in either of the two flanking categories (Tastle and Weirman 2008).

This has led to the development of an Agreement measure (equation 4):

$$Agr(x, \tau) = 1 + \sum_{i=1}^n p_i \log_2 \left(1 - \frac{|x_i - \tau|}{2d_x} \right) \text{-----} (4)$$

$\tau = target (1,2,3,4 \text{ or } 5), d_x = x_{max} - x_{min} = 4 (here), p_i = \frac{f_i}{n}. 0 \leq Agr(x, \tau) \leq 1$

In this study, the consensus and agreement results are combined in order to generalise the results and accurately reflect the preferences of the stakeholders and the cane farmers. In addition to these measures additional socio demographic data items were collected and the results examined in light of these items. Open-ended responses were used to give increased meaning to the results based on the participant's explanation and contextualising language.

5. Study area and survey participants

Cane growing and sugar production have been around for more than hundred years in Australia. It has been a catalyst for the development of many coastal settlements and underpins the economic stability of many rural townships. It is one of Australia's most important rural industries, worth over AUD1.5–2.5 billion to the Australian economy (Canegrowers, 2010). Around 366,639 hectares of land is cultivated to grow sugar cane and this produces approximately 27.9 million tons of cane and 3.7 million tons of sugar in 2011 (Canegrowers, 2012). Sugar cane production occurs predominantly in coastal Queensland localities (est. 94%⁴) and in some coastal areas of northern New South Wales (est. 5%) (Figure 4).

⁴ Estimated percentage of sugar cane grown in Queensland and New South Wales

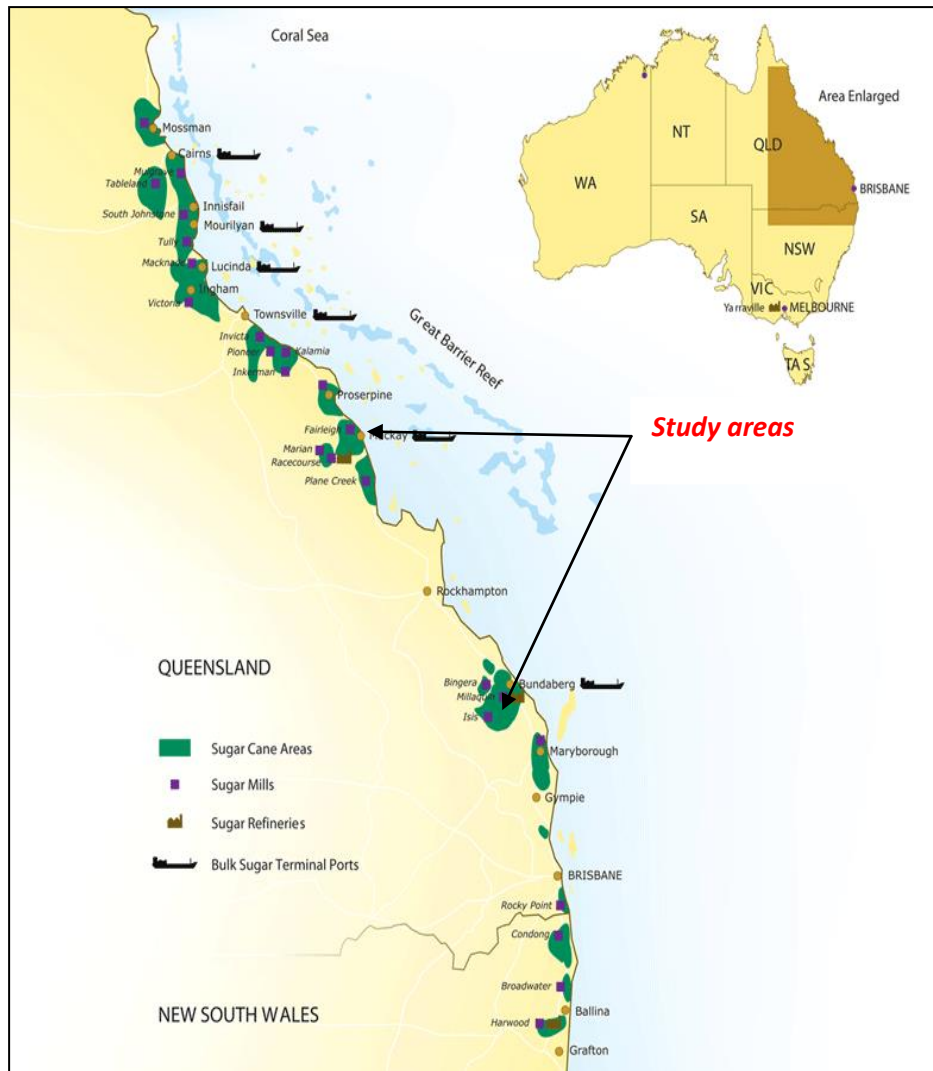


Figure 4 Sugar cane areas in Queensland and NSW and study areas (Source: Canegrowers, 2010)

The commercial production of sugar cane in Australia is dependent on particular climatic conditions, soil characteristics, topology as well as supporting social and economic norms and institutions. Australia has six main climate zones⁵ that effectively limit the production of sugar cane to specific locations.

This study chose two substantial sugar cane growing areas, the Bundaberg and Mackay regions which are situated in subtropical climate zones and have adequate rainfall for successful sugar cane production (Figure 4).

The Bundaberg region is a high growth area in Queensland (BRC, 2009). The Bundaberg regional economy is most reliant on the five sectors: Manufacturing (13.3%), Agriculture, Forestry and Fishing (11.6%), Retail Trade (8.0%), Health and Community Services (7.4%), and Education (6.0%) (BRC, 2009). The first sugar mill (Fairymead Mill, which is now called Bundaberg Sugar Mill) in the Bundaberg region was established in 1880. The Bundaberg region includes approximately 920 sugar cane farmers with a total crop area of about 59,000

⁵ Based on the Köppen classification (BoM, 2005)

hectares, who service six sugar mills within the Bundaberg Sugar Ltd and these mills crush approximately 4.3 million tonnes of cane every year (Bundaberg Sugar, 2008). Many other industries such as engineering farms, wine industries, haul-transportation system and sugar farms support industries are heavily reliant on the sugarcane farming in this region.

Current land management practices and their potential consequences for land and water degradation were comprehensively reviewed in 2003 by the Productivity Commission. LRAM (2004) reviewed the Productivity Commission Report (2003). LRAM (2004) found that the most farmers were not practicing the LMPs with a view to maintain the water quality at paddock level and also to maintain ecological sustainability. For example, they found there was a loss of ground cover, stream bank erosion, overuse or misapplication of fertiliser, loss of riparian filters, untreated urban sewerage and stormwater, overuse or misapplication of herbicides and pesticides, disturbing potential acid sulphate soils and over irrigating (LRAM, 2004). Therefore this is a time study for the Bundaberg region that this study has the opportunity to investigate these LMPs after a nine year period of this report.

The Mackay region is underpinned by significant coal-mining deposits in the Bowen and Galilee basins and is home to one of Australia's largest sugar growing and milling industries (MRC, 2012). The sugar industry has existed in the Mackay region since the 1860s and Mackay Sugar Co-operative Association Limited (Mackay Sugar) was formed in 1988, is one of Australia's largest agricultural co-operatives and produces more than 20% of Australia's raw sugar production – the second largest producer in the Queensland industry (MSCA, 2008). It currently operates the Racecourse, Farleigh, Pleystowe and Marian mills, which cover 75, 489 hectares of cane harvested area, process up to 6.6 to 8 million tonnes of cane in a crushing season with an average of 313.4 million revenue and 5.5 million profits (Mackay Sugar, 2008).

Prime agricultural land for cane farming is not much available in Mackay for a sustainable cane farming in that region (Geno, 1996) and recently this situation has been exacerbated by the intrusion of urban and industrial development into the cane farming areas (Greer et al. 2012). Also traditional cane farming over the last 100 year, the region has resulted in widespread and occasionally substantially degradation along with heavily used of chemicals and fertilisers (Geno, 1996). Mitchell et al. (2005) found a high concentration of herbicides within the fresh water bodies in the Mackay region and they identified that the herbicides used in the sugarcane cultivation were the most likely source of herbicides residues and nutrients found. However over the last decade, land management practices in this region have been changing with improved cane varieties, minimum levels of chemicals, fertilisers and machinery; therefore this is a timely case study to see how the farmers are making adoption decisions and what factors are influencing them to adopt improved LMPs, especially to adopt 'B' category LMPs.

5.1 Characteristics of the survey participants

The Bundaberg and Mackay cane farmers were mostly full time farmers (80% and 78.5% respectively) and generally classified their role on the farm as the owner and manager (90% both locations). The majority of farmers had ownership of the farming property although a

higher percentage of farmers were involved in shared ownership/leasing arrangements in the Mackay area than Bundaberg region (Figure 5).

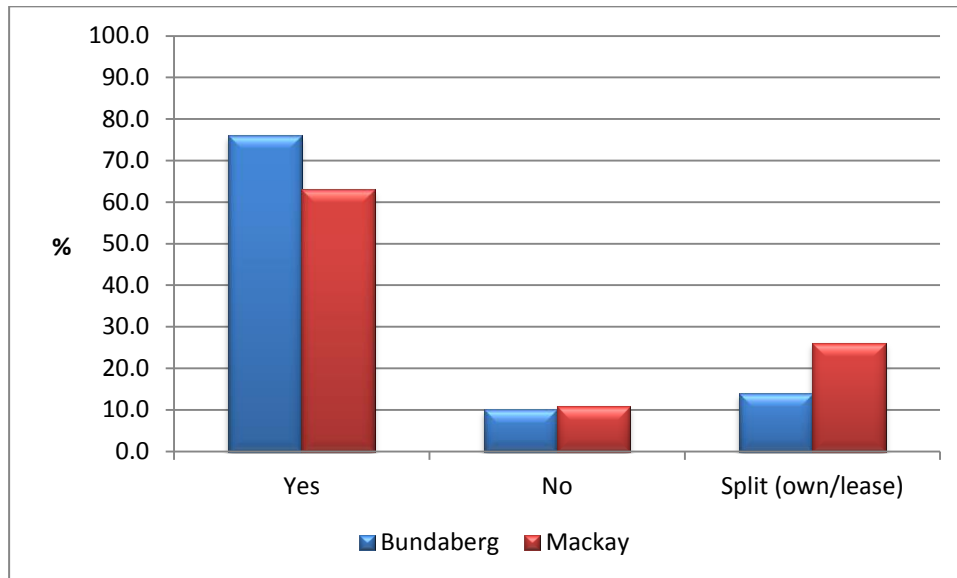


Figure 5 Ownership of farming land

The majority of the farmers were aged between 35 and 54 years with the Mackay cohort being slightly younger than the Bundaberg cohort (Figure 6). The survey managed to capture the opinions of a significant group of 'under 35 years' farmers ensuring a well-represented sample of cane growers in both regions.

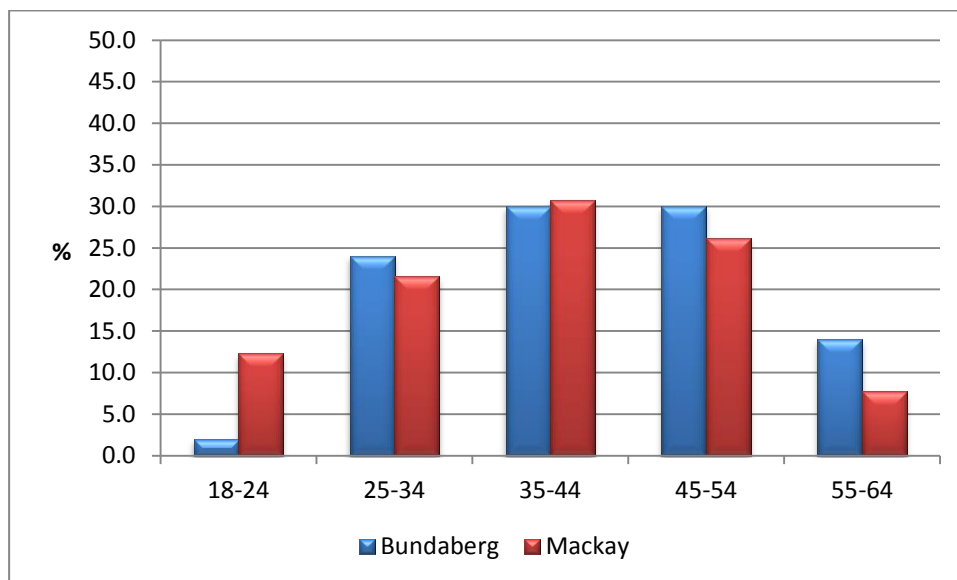


Figure 6 Participant age category (years)

The survey respondents represent a highly skilled and experienced cohort of farmers with over 70% of the Mackay respondents and 66% of the Bundaberg respondents having over 20 years' experience in cane farming. One third of the Mackay cane farmers had between 31-40 years in farming (Figure 7).

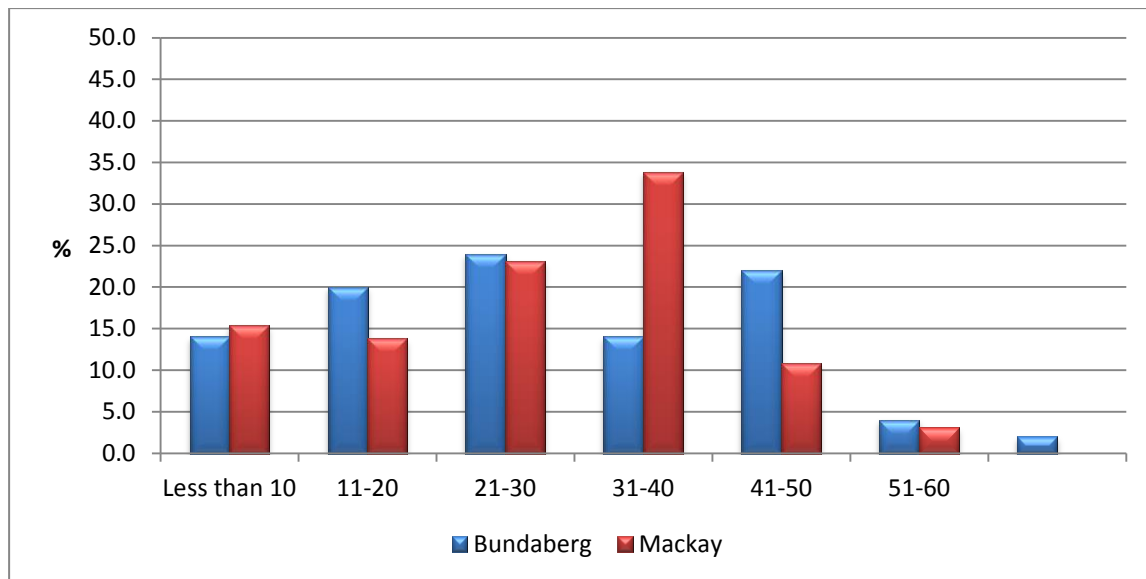


Figure 7 Years in farming

The majority of the farmers had 2-3 children with the Mackay Whitsunday cohort having the highest number of farmers with no children (15%) as well as the highest number of three and four children families (Figure 8).

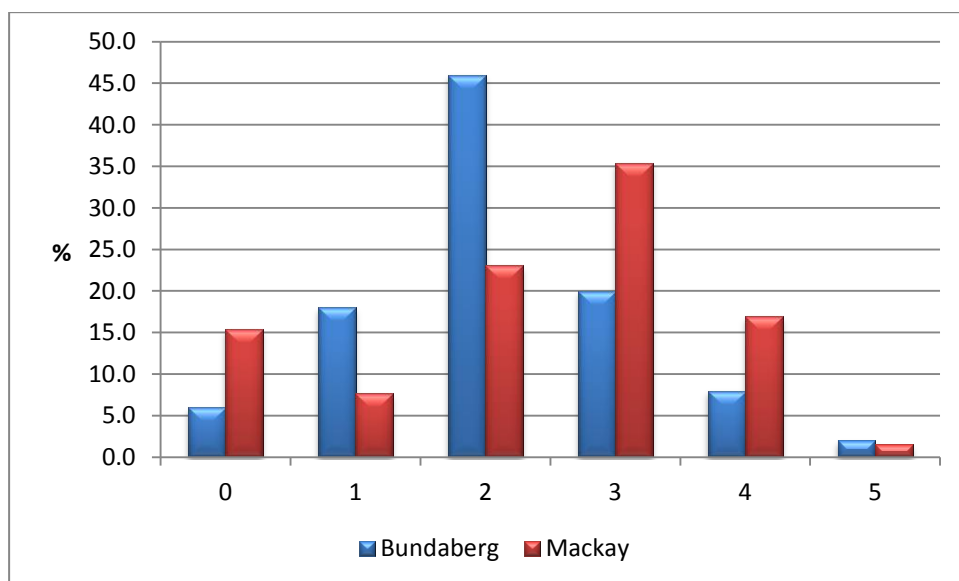


Figure 8 Number of children

A larger proportion of the Mackay cane farms do not have any family members working on the property with 41.5% compared to Bundaberg cane farms with 16%. Thirty eight % of Bundaberg cane farms have one other family member working on the property (Figure 9).

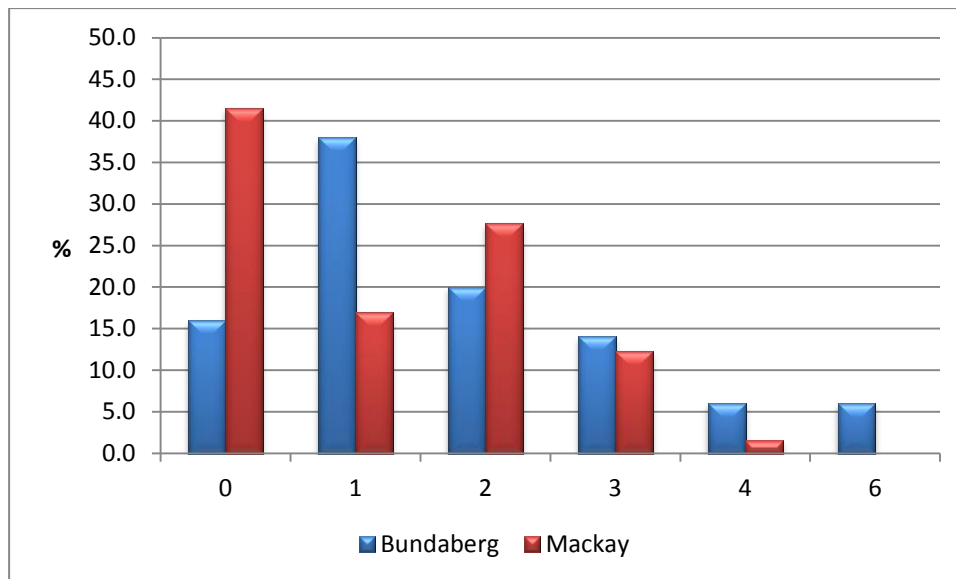


Figure 9 Family members working on farm

The majority of cane farmers indicated that secondary education is the highest level of education obtained with some small variations between the Bundaberg and Mackay cohorts regarding vocational/TAFE and tertiary qualifications. More Mackay cane farmers have a vocational/TAFE qualification (17.5%, 4.1%) and the reverse is the case for tertiary qualifications with Bundaberg 34.7% and Mackay 12.7% (Figure 10).

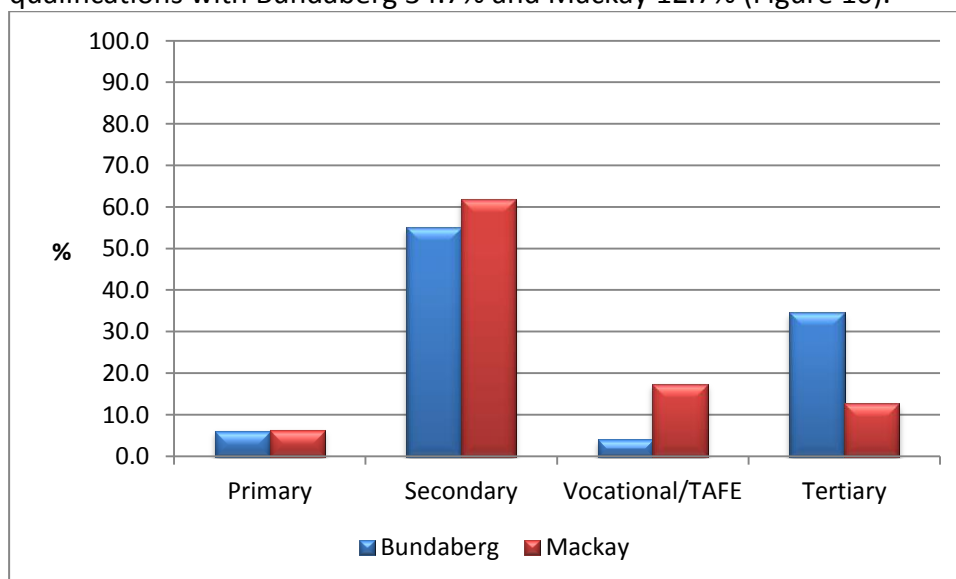


Figure 10 Highest level of education

At least a third of cane farmers in the Bundaberg region do not have any off-farm income compared to only 3.1% of Mackay cane growers. The majority of Mackay cane growers (53.8%) however derive up to 20% of their income from off-farm sources which compares to the Bundaberg region with 34% (Figure 11).

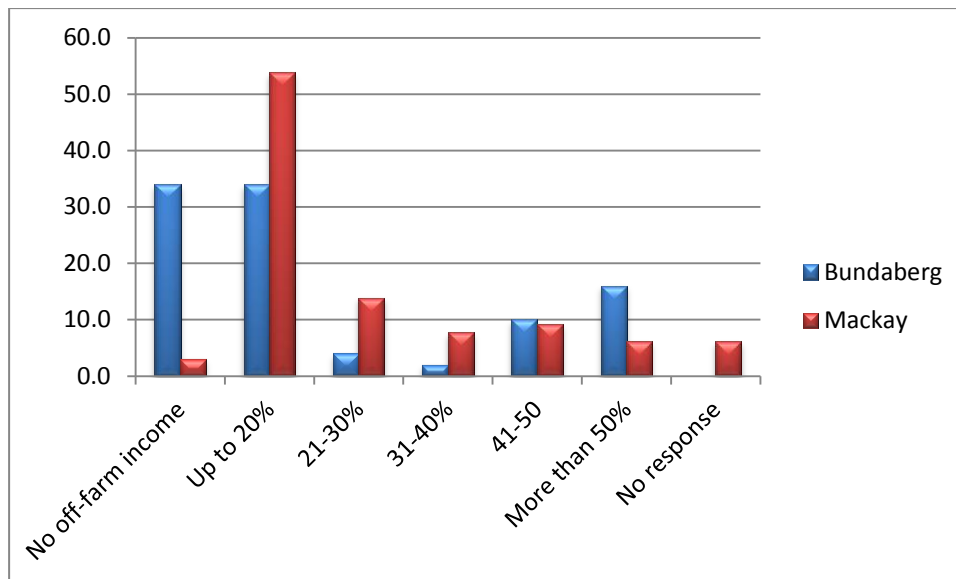


Figure 11 Family income from off-farm sources

A significantly large proportion of Bundaberg cane growers (84%) expressed the view that their cane farms are currently profitable compared to the Mackay region with 56.9% (Figure 12). A third of the Mackay cane growers (35.4%) believe that their cane farms are currently economically steady with just a very small proportion rating their properties as unprofitable (6.2%, Mackay).

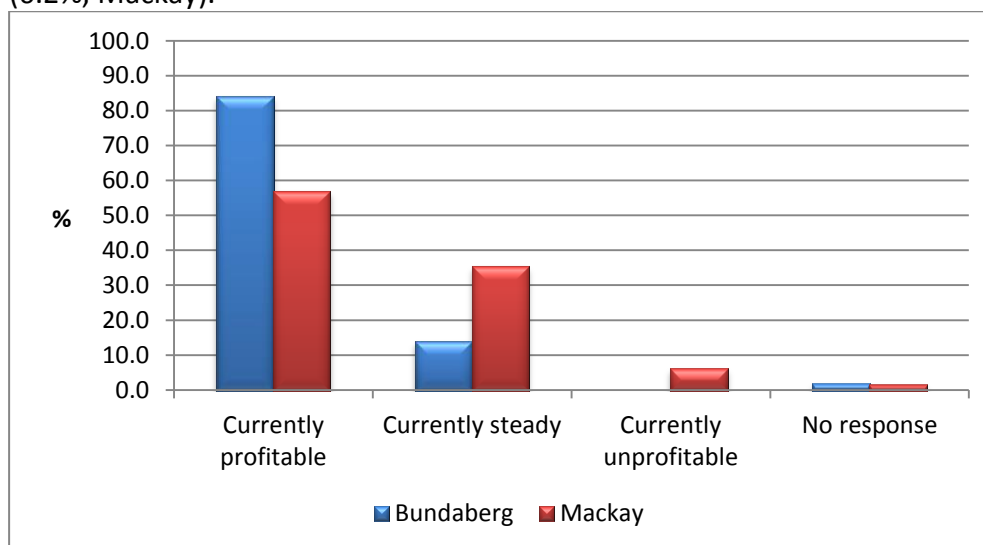


Figure 12 Farm profitability

5.2 Characteristics of cane farms in study area

Approximately 42% of the area of land that is managed for cane production by the survey participants is between 101 and 250 hectares. The main differences between the Bundaberg and Mackay regions is a higher number of smaller land parcels set aside for cane production (less than 100 hectares) in the Bundaberg region and the higher number of Mackay based cane operations that were between 251 and 500 hectares (Figure 13).

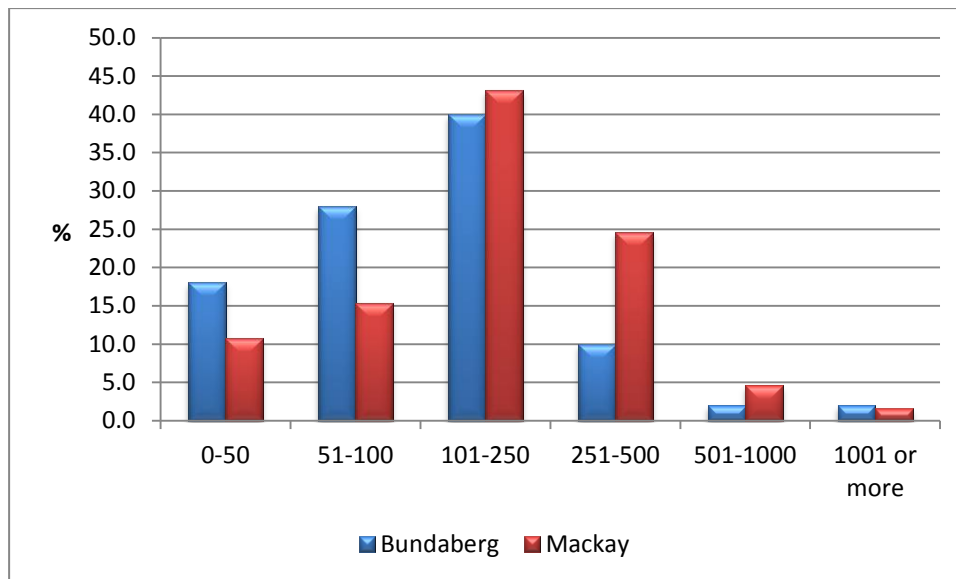


Figure 13 Area of land for sugarcane production (hectares)

Just over a half (58.3%) of all cane farmers surveyed harvested less than 125 tonnes per hectare on average over the last five years, however the data reveals a substantially different harvest profile between Bundaberg and Mackay cane growers. The majority of cane farmers in the Bundaberg region harvested between 76–100 tonnes per hectare whereas in the Mackay region the average was between 126–150 tonnes per hectare. There were also approximately a third of the Mackay cane growers who harvested 151 tonnes per hectare or more compared Bundaberg which did not record any cane growers achieving this harvest rate (Figure 14), however the figures those are more than 100 tonnes per hectare look like overstated by the farmers because sugarcane yield per hectare is about 100 tonne in Australia (O’Connell, 2009).

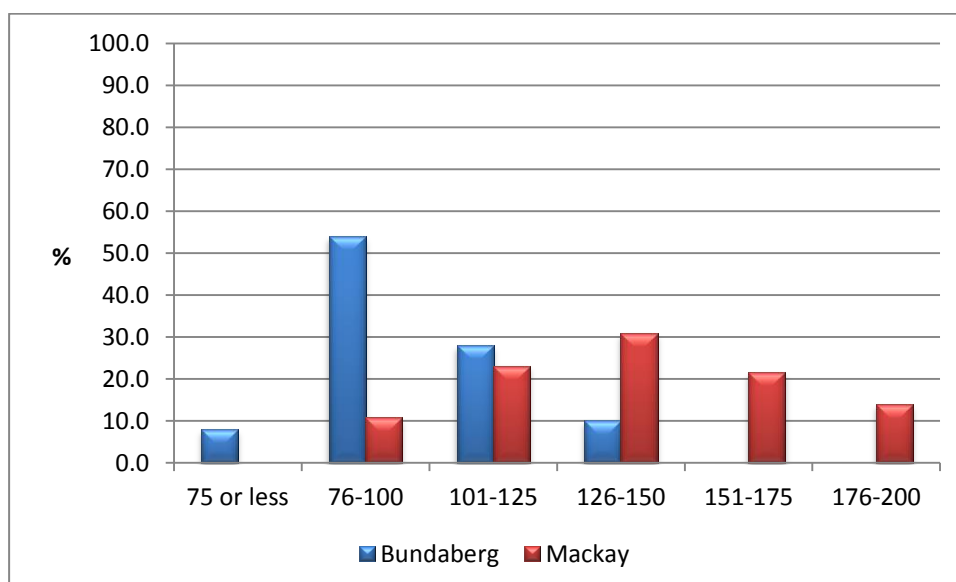


Figure 14 Average cane harvests over last five years (tonnes/hectare)

A higher diversity of soil types was recorded in the Mackay region with 35.8% of cane farmers indicating all types of soil on their farms compared to Bundaberg with only 8% (Figure 15).

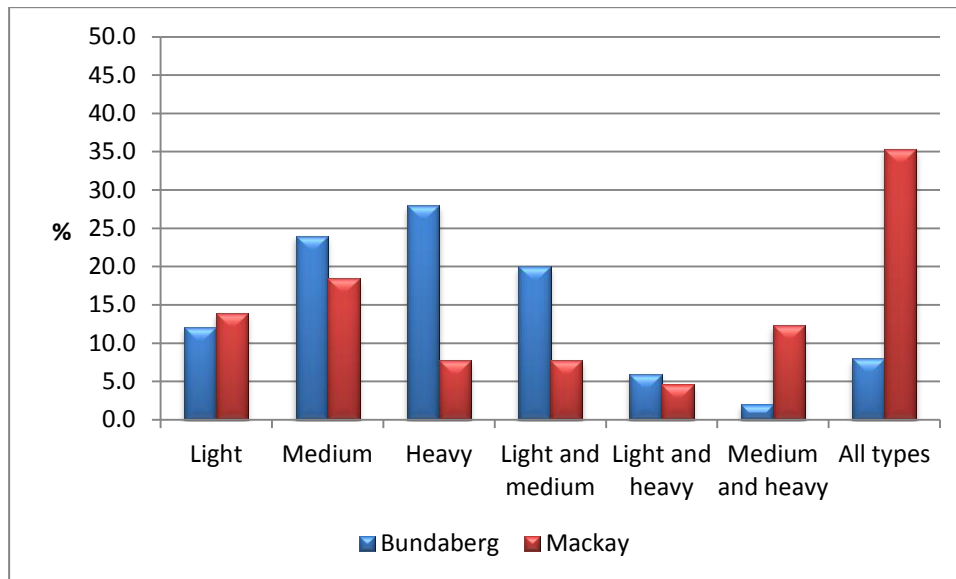


Figure 15 Main soil texture on farm

Based on the survey data the majority (80%) of Bundaberg cane farms have less than 3% slope compared to Mackay with 40% (Figure 16).

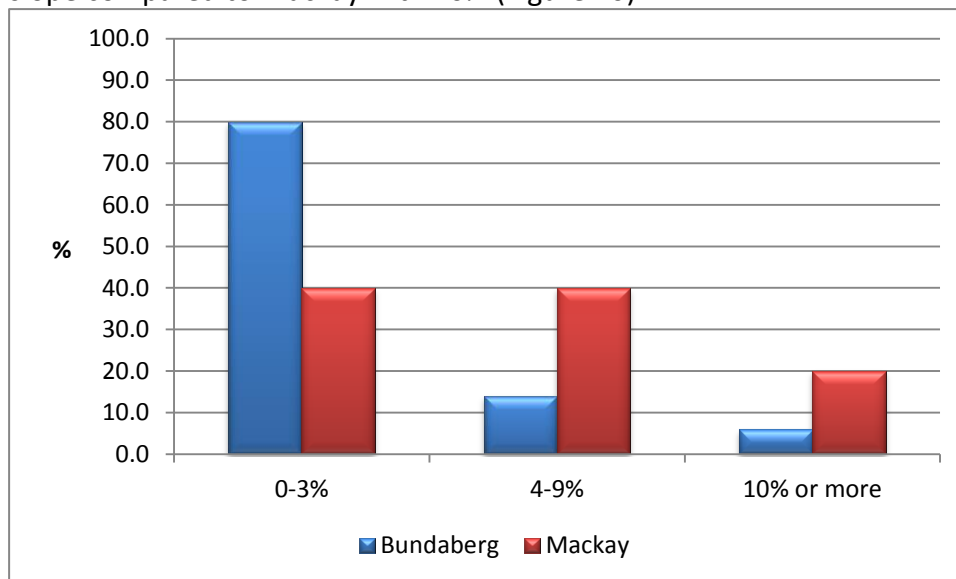


Figure 16 Proportion of slope on farm

The survey of cane farmers examined the contracting practices of cane farmers as these may be influential with regard to the adoption of LMPs (Figure 17).

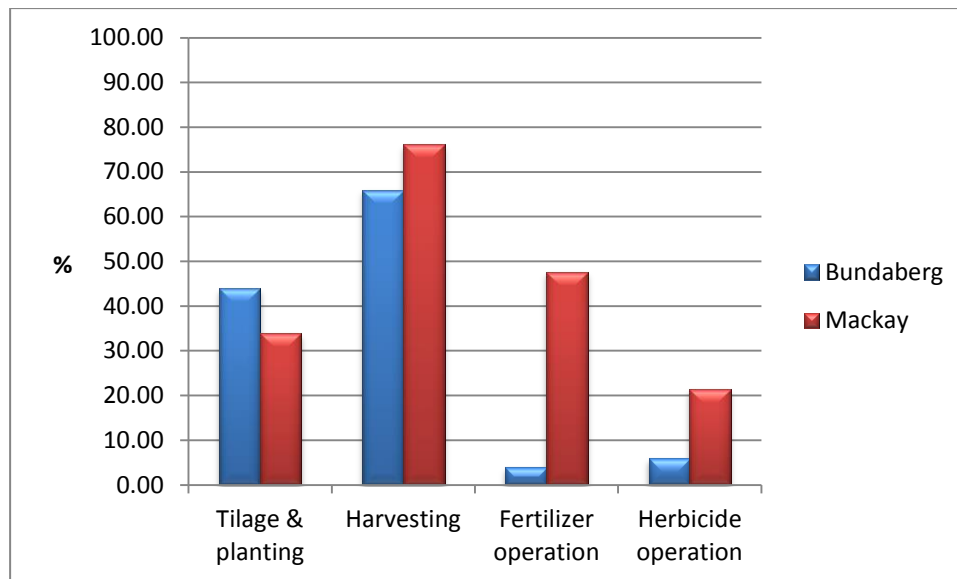


Figure 17 Percentage of farmers who contract out LMPs (regular or occasional)

6. Results

The study identified key variables under four major factors (socio-demographic, cultural, and economic and support services) that may influence farmers' attitude and behaviours in LMPs adoption decisions. The four major factors are consistent with the behavioural theories of adoption of agriculture practices and draw substantially from the literature reviewed in the study (Hoffman, 2006; Rogers, 2003; Lockie et al. 2002; Willock et al. 1999; Ajzen, 1991). This section provides stakeholders' responses about the factors affecting the adoption of LMPs that have water quality benefits and is followed by cane farmers' responses. Here we also used the mean value of participants' responses (raw data) to show the variation of mean value with the consensus and agreement level.

6.1. Stakeholders' responses

Overall the stakeholder ratings of the adoption factors in the four main categories resulted in the highest average consensus and agreement values in the 'support services' category with an average measure for consensus of 78.37% and agreement at 78.31% resulting in a combined measure of 78.34% (Table 3). Here the consensus and agreement scale is between 0% and 100%, where 0% means there is no consensus or agreement with the issue/factor and 100% mean a complete consensus and agreement.

Table 3 Overall stakeholder results by adoption factors: consensus and agreement

Category of factors	Average of category factors		
	Consensus	Agreement	Combined (%)
Support services	78.37	78.31	78.34
Economic	75.4	66.05	70.73
Cultural	77.24	62.69	69.96
Socio-demographic	75.05	54.39	64.72
Average	76.52	65.36	70.94

The results of each of the variables in the four categories are presented in order of the combined support shown by the stakeholders. Out of 17 stakeholders, thirteen of the stakeholders also provided informative comments about the current LMPs and the factors influencing the LMPs adoption. The majority of the comments relate to support services, economic and cultural factors highlighting the importance of these in influencing the adoption of LMPs. The comments also illustrate the high level of interconnectedness between the factors influencing adoption decision making. The comments are under appropriate factor.

Support services:

Stakeholders recognised all support services as important factors influencing adoption of LMPs, with free scientific advice (from the government), trials and demonstration for new LPMs and the provision of training and information rating as the most important factors affecting the LMPs of cane farming (Table 3). However both consensus and agreement with availability of scientific advice, trials and demonstration and subsidies programs, are very high (more than 80%).

Table 4 Stakeholders' consensus and agreement with support services

Support services	Mean value	Consensus (%)	Agreement with '5' (%)	Combined (%)
Availability of scientific advice from local agricultural extension officer can increase adoption of LMPs	4.02	81.81	81.34	81.58
Government funding for demonstrations and trials of new LMPs can increase adoption of LMPs	4.02	81.81	81.34	81.58
Government subsidies to adopt a new LMP by the farmers can increase adoption of LMPs	4.275	75.53	87.19	81.36
Information provision and training including risk management can increase adoption of LMPs	3.863	81.77	77.53	79.65
Availability of scientific advice from private consultants can increase adoption of LMPs	3.284	70.91	64.15	67.53

A critical element of the support services is the combination of providing strong supported advice to growers which is not only based on good science but is also demonstrated as cost effective with targeted financial incentives.

'Any LMPs that can be physically demonstrate by the scientific society or by the government and then make appropriate promotion of such practices can be a one of the best mechanisms to promote LMPs that have water quality benefits' (Stakeholder 07⁶).

As stated above the importance of being able to demonstrate best practice LMPs in a way that illustrates benefits not only to the environment but also to the productivity of the farming operation is important.

⁶ Stakeholders remain unidentified throughout this report.

'Farmers can be convinced in using LMPs that have water quality benefits if data and trials demonstrate that there would be no financial loss in adopting a practice that have water quality benefits' (Stakeholder 01).

Governments are in a position to facilitate key drivers of change via the introduction and continuation of specific incentives to activate farmers to seek change and improve environmental outcomes while becoming more efficient.

'Industry and the growers are also looking for some award from the government in recognising the farmers and the extension officer services for using LMPs that have water quality benefits' (Stakeholder 01).

However the stakeholders also point to concerns that they have regarding the current progress of support services for the cane farming sector. The follow is a selection of the main issues raised by the stakeholders during their interviews.

The stakeholders were concerned about the communication and co-ordination of initiatives to promote change behaviour towards best practice LMPs. This concern was addressed to differing scales for example there was criticism of 'institutional barriers in the region' (Stakeholder 02) and of improvement needed in inter-organisational relationships such as between the 'local NRM group, BSES and canegrowers'. The concept of a 'one stop shop for getting extension services and advice' was suggested as a possible way to re-organised the limited resource available for the promotion of best practice LMPs (Stakeholder 02).

While the RRRD projects were seen to make 'positive changes in LMPs adoption by the cane farmers' (Stakeholder 03), the farmers were characterised by some stakeholders as having limit time to digest the required knowledge to fully assess new practices and that subsequently the adoption process is understandably slow and requires a concerted effort through the diverse communication channels that are available. For example, 'The majority of farmers also need assistance in the application process for funding, either because of lack of time or skills' (Stakeholder 10). Communication via peer groups was seen as a critical facilitating process of knowledge transfer which be backed by appropriate support services (Stakeholder 06).

An important point in the adoption of new LMPs is that, 'Some farmers are early adopter while some are late adopter. Question always arise who will make the decision and why they make the decision. However introducing a new technology is always a challenge and it requires demonstrated benefits to the farmers' (Stakeholder 07). Support services can be viewed as providing some level of assurance against the risk of adoption of best practice LMPs, in doing that the support services need to be both consistent in message but also diverse in the use of communication channels.

Communication of support services needs to reflect the diversity of the receiving cohort which can range from new technology early adopters to those who have more traditional practices and lifestyles (Stakeholder 04). As one stakeholder points out, 'Canegrowers newsletters need to be equipped with most recent technical and market information of this sector and it should be widely circulated within the cane farmers and the stakeholders.

Online newsletter is fine but many farmers do not look at this online, however a glossy and well-pictured magazine can increase the interest of farmers' (Stakeholder 06).

Economic factors:

Among the economic factors (n=9), financial incentives has been considered as the most influential factor affecting the farmers decision in adopting LMPs that have water quality benefit (Table 5). Flow of funds for operation and maintenance of the farm and long term goal of profit are also among the important economic factors in terms of stakeholder's consensus and agreement (Table 5).

Table 5 Stakeholders' consensus and agreement with economic factors

Economic factors	Mean value	Consensus (%)	Agreement with '5' (%)	Combined (%)
Financial incentives can increase adoption of LMPs	4.588	83.98	94.33	89.16
Availability of operation and maintenance funds can increase adoption of LMPs	3.686	76.65	73.85	75.25
Farmers with a long term profit goal are more likely to adopt LMPs	3.365	79.41	66.65	73.03
Farmers having risk management planning are more likely to adopt LMPs	3.438	77.74	67.97	72.86
Farmers having strategic business planning are more likely to adopt LMPs	3.333	74.9	65.37	70.14
Farmers focused on minimising costs are more likely to adopt LMPs	3.392	69.9	66.83	68.37
Farmers who make large profits are more likely to adopt LMPs	3.167	70.55	61.29	65.92
Increase of farm/land value can increase adoption of LMPs	2.688	79.61	50.02	64.82
Farmers having quarterly or monthly budget and cost controls are more likely to adopt LMPs	2.689	65.9	48.13	57.02

The sensitivity of cane farming to operational costs and profit margins is seen as directly related to not only the capacity of farmers to adopt new LMPs but also the willingness (Stakeholder 06). As pointed out by one stakeholder, *'Some farmers are also convinced by evidence that show environmental benefits, however showing environmental benefits is not enough for the cane growers and most of them are looking for win-win situation'* (Stakeholder 01), and *'New LMP adoption depends on input and labour cost'* (Stakeholder 09).

The stakeholders pointed to the relative success of the Reef Rescue program despite financial pressures, *'the margin squeeze on profits has been detrimental to adoption on new LMP's. Success has been achieved through the RR program in the Central region due to a reasonable level of incentives with a >60% adoption rate of LMP's. This indicates that growers intrinsically feel it benefits their agronomic and economic bottom line'* (Stakeholder 04).

While the Reef Rescue program with the provision of subsidies is strongly supported, *'Working with farmers and providing subsidies will achieve far quicker adoption of LMP's than Government legislation. This has been proven via the uptake of funding through the*

Reef Rescue project' (Stakeholder 12) there is some caution. The adoption of best practice LMPs has been successful however the uptake of LMPs is not uniform with those who have acquired sufficient knowledge of the benefits of new practice more likely to adopt however, 'the balance will choose only those technologies which are less capital intensive but give some agronomic benefit' (Stakeholder 04).

Cultural factors:

According to the stakeholder's those farmers with a desire for protecting natural resources and those with an openness to current and scientific knowledge of farming are more likely to adopt LMPs with water quality benefits (Table 6). The result for farmers who are 'following traditional local knowledge about farming' is interesting because it raises questions regarding the standing of traditional knowledge among stakeholders. It is also of interest as it highlights the challenge of the consensus and agreement approach with the results showing a high level of consensus but a low measure of agreement, which means the stakeholders might have a high level of consensus about the impacts of a particular factor towards the average perception (mean) of the overall participants but might have lower level of agreement towards the highest level of impact or adoption. Therefore, with both higher level of consensus and agreement towards any particular factor should attract more attention to the stakeholders and policy makers about the future investment and decision making for this sector.

Table 6. Stakeholders' consensus and agreement with cultural factors

Cultural factors	Mean value	Consensus (%)	Agreement with '5' (%)	Combined (%)
Farmers desiring to protect natural resources are more likely to adopt LMPs	3.917	85.65	78.97	82.31
Farmer's self-awareness and openness to current and scientific knowledge about farming increases adoption of LMPs	3.969	83.37	79.92	81.645
Peer influence can increase adoption of LMPs	3.589	77.82	71.64	74.73
Embedded capacity of the farmers to manage the farm can increase adoption of LMPs	3.552	74.95	70.57	72.76
Farmers following the practice of others in their community are more likely to adopt LMPs	3.125	82.28	60.77	71.525
Family members can influence adoption of LMPs	3.313	75.79	64.94	70.365
Community connectedness can increase adoption of LMPs	3.198	78.3	61.79	70.045
Farmers focusing on controlling own practice are more likely to adopt LMPs	3.323	74.44	64.57	69.505
Lifestyle choice as being a farmer can increase adoption of LMPs	2.688	71.97	49.51	60.74
Farmers following traditional local knowledge about farming are more likely to adopt LMPs	2.26	81.44	38.4	59.92
Social prestige as being a farmers can increase adoption of LMPs	2.708	63.61	48.52	56.065

Stakeholders mentioned the importance of good leadership from industry organisations and NRM groups in relation to the transformative role that it can play for changing the culture of cane farming and being influential on the values ascribed to LMPs. For example, *'a good manager within the Canegrowers association or in the local NRM body helps the farmers to share up to date scientific information.....doing things different or implementing any innovative method is part of an integrated behaviour between the farmers and the managers'* (Stakeholder 08).

Decision making in relation to new LMPs with a family based farming operation can also sometimes be a complex arrangement. For example, *'Grandparents holds the cheque books, parents are directly working in the field and are dealing with all farming activities with the internal and contractors' workforce. Grand children usually do some record keeping work. Farmer's attitudes towards risk and uncertainty influence the adoption of LMPs. They are always looking what their neighbours doing'* (Stakeholder 06). Of importance it would seem is the integration or translation of best practice objectives, the way farm extension action are interpreted, and the realities that confront cane growers. In short the multiple drivers of the change process. For example, *'Farmers like traditional way of things happening. However they confined by strong cultural norms and practices and they are not much worry about peer influence but the mills influence. Mills are connected with the sugar market and are looking for profit maximisation and therefore it is becoming a culture for the farmers to maximise their production'* (Stakeholder 08).

Farming culture and practice cannot be assumed to be homogeneous as farmers have differing *'feelings towards the environmental stewardship of the practices'* (Stakeholder 06). In some locations there are differing regulations regarding practices that may impact on the GBR and farm practices have their own history and cultural influence. Understanding the cultural drivers as they shape farming practices is an important first step in translating objectives, technological development and changed farm management systems' (Stakeholder 06).

Socio-demographic factors:

The results shown in Table 6 have been ordered by the highest combined score for consensus and agreement for each of the socio-demographic factors. The combined consensus and agreement scores show that the socio-demographic factors which are considered more likely to influence adoption of LMPs are the age of the farmer with 'younger farmers' more likely to adopt LMPs that have water quality benefits, farmers that have a succession plan in place, and those farmers who own their farm (Table 7). However in the past, Norris and Batie (1987) conducted a study on 'adoption of soil conservation practices' and they found the similar findings. However not many study in recent times has conducted such type of study or even found such findings.

Table 7. Stakeholders' consensus and agreement with socio-demographic factors

Socio-demographic factors	Mean value	Consensus (%)	Agreement with '5' (%)	Combined (%)
Younger farmers are more likely to adopt LMPs than older farmers	3.625	79.4	72.14	75.77
Farmers having a succession plan are more likely to adopt LMPs	3.427	74.96	67.786	71.373
Ownership of a farm helps motivate to adopt LMPs	3.604	69.77	71.51	70.64
Farmers having an intention to expand the farm size helps adopt LMPs	3.24	75.33	63.36	69.345
Family involvement in farming increases adoption of LMPs	2.875	82.27	54.7	68.485
Full-time farmers are more likely to adopt LMPs than part-time or hobby farmers	3.198	69.58	61.28	65.43
The higher the education/training level of the farmers, the better the adoption rate	3.427	64.11	66.72	65.415
The bigger the farm size, the more likely the adoption	3.188	66.44	61.39	63.915
Farmers with long term involvement with farming are more likely to adopt LMPs	2.198	83.87	36.75	60.31
Farmers with off-farm income are more likely to adopt LMPs	2.323	79.61	40.05	59.83
Female farmers are more likely to adopt LMPs than male farmers	2.458	71.67	42.71	57.19
Farmers planning to exit the industry are more likely to adopt LMPs	2.031	83.37	30.84	57.105
Having outside labour involved in farming increase adoption of LMPs	2.271	75.32	37.77	56.545

In some cases socio-demographic factors have scored quite highly on the consensus measure but this has not been replicated with the agreement measure because the farmers have consensus with average importance with the factor but not agree with the highest level of importance, for example, farmers have very high level of consensus (83.67%) that a long term involvement with farming enhance the likeliness to adopt LMPs that have water quality benefits but most of them agree with such consensus with around average value of importance scale i.e., around 3 out of 5 scale but their agreement with highest level of agreement (i.e. 5) is poor (36.75%). All of these factors have a combined score indicating support of more than 70%, which is more than average support.

The stakeholders generally expressed the view that socio-demographic factors were important constraints to changing LMPs from more traditional practices to innovative and environmentally sensitive practices. The management of the cane farm can be complex and interact with other farming and economic activity and involve a number of family members. For example, *'Farmers' wives are playing important financial planning roles in cane farming such as they are usually maintain record keeping of money flows. Sometimes farmers' older children, who are in early 20s, are also helping their dads in record keeping (Stakeholder 01).*

Social and cultural factors were seen by stakeholders to be as equally important as economic and physical factors (Stakeholder 09). Factors such as the age and past career as a farmer

were seen to be just as important as the size of the farm and any 'economy of scale' advantages in adoption decisions (Stakeholder 06).

The stakeholders raised the issue of mono-cropping suggesting that differing mixed farming operations may reduce nutrient and herbicide flows into the GBR however even with changed farming practices there remains the issue of variations in practices even by new LMP adopters (Stakeholder 05). An increased focus on social issues regarding change behaviour of farmers, in particular integrated approaches was recommended by stakeholders (Stakeholder 11).

6.2. Farmers' responses

The study surveyed 112 sugar cane farmers in the Mackay and Bundaberg regions seeking information on the relevance of particular LMPs with water quality benefits. In addition to the relevance of the LMPs the survey also sought to measure the importance of selected socio-demographic factors that may serve as a limiting factor to manage the farm with beneficial LMPs. Three broad categories of land management practices in cane farming were identified by previous research that impact on the water quality within the Bundaberg and Mackay region (Brodie et al. 2012; Rohde et al. 2011; DPIF, 2009; Drewry et al. 2008; Thornburn et al. 2007), were tested again by the farmers of these regions and the test results are given below in the form of consensus and agreement values.

The overall results of these are presented in Table 8. There were six specific practices related to 'nutrient and herbicide management' which achieved the highest combined consensus and agreement measure of 70.14%. This was followed by 'soil and erosion management' with five specific practices with 61.48% combined consensus and agreement and then 'water and irrigation management' with five practices as well, with 50.28%.

Table 8 Farmer consensus with LMP categories

	Consensus (%)	Agreement with '5' (%)	Combined (%)
Nutrient and Herbicide Management practices (n=6)	64.54	75.74	70.14
Soil and erosion management practices (n=5)	54.29	68.67	61.48
Water and irrigation management practices (n=5)	45.72	54.84	50.28

The results of the specific LMPs are shown in the following tables sorted by the highest combined consensus and agreement values within each of the three LMP categories. The results are shown for the level of relevance to sugar cane farmers on the basis of consensus and agreement values.

Results are also shown for the importance of selected factors for limiting the ability of farmers to adopt the LMPs presented in the survey. These are illustrated in the three categories and comparisons made between each of the categories.

Six nutrient and herbicides management practices were presented to the cane farmers in the survey in order to calculate the average consensus and agreement values for each of the 'nutrient and herbicide' LMPs. Although all of the LMPs scored higher than 50% (i.e., average consensus and agreement), four of these LMPs scored higher than 70% combined consensus

and agreement. These include, in order of preference, 'Timing nutrient/pesticides application with respect to crop stage, irrigation and rainfall', 'Application rates of fertiliser/pesticides based on latest industry recommendations', 'Soil test fallow block each year', 'Variable rate of fertilizer/pesticides between blocks' (Table 9).

Table 9 Farmers' consensus and agreement with the relevance of nutrient and herbicides management practices

Nutrient and Herbicide Management practices (n=6)	Mean score	Consensus (%)	Agreement with '5' (%)	Combined (%)
Timing nutrient/pesticides application with respect to crop stage, irrigation and rainfall	4.126	70.03	83.42	76.73
Application rates of fertiliser/pesticides based on latest industry recommendations	3.947	73.17	79.24	76.21
Soil test fallow block each year	3.942	67.19	78.77	72.98
Variable rate of fertilizer/pesticides between blocks	3.873	66.84	77.49	72.17
Record kept in paddock journal	3.568	59.69	69.95	64.82
Using sub-surface or slow-release fertiliser	3.42	50.29	65.55	57.92

Eight factors were considered to be more important with over 75% support from the farmers and half of these are economic factors and the other half of these are social and cultural factors (Table 10). However, partner's involvement and intention to expand the firm size have less than average scores, and social prestige and life style choice has an average score (Table 10), which indicate that these factors are not influencing much to the farmers in making adoption decision regarding improved nutrient and herbicide management.

Table 10 Farmers' consensus and agreement with the importance of the factors that influence the above nutrient and herbicide management practices

Factors affecting nutrient & herbicide management	Mean score	Consensus (%)	Agreement with '5' (%)	Combined (%)
Maintain a long term steady profit	4.275	73.12	86.85	79.99
Maximise profit and minimise labour and overhead costs	4.294	71.92	87.34	79.63
Self-awareness and openness to current and scientific knowledge	4.067	73.07	82.14	77.61
Maintaining a quarterly budget, cost control and risk management plan	4.076	72.1	82.22	77.16
Access to and availability of cash flow (operation and maintenance funds)	4.053	70.75	81.43	76.09
Long term involvement with farming	4.038	70.46	81.4	75.93
Access to and availability of information and training	3.943	72.39	79.31	75.85
Self-desire to protect natural resources	4.057	69.03	81.55	75.29
Focus on controlling own practice	3.99	67.85	79.94	73.90
Government funding/subsidies for trials of new nutrient and herbicide practices	3.864	70.04	77.26	73.65
Support services from the extension officer and private consultant	3.854	69.57	77.15	73.36

Factors affecting nutrient & herbicide management	Mean score	Consensus (%)	Agreement with '5' (%)	Combined (%)
Working full-time in the farm	3.898	64.49	77.72	71.11
Uncertainty over selling markets	3.551	58.39	69.17	63.78
Freehold ownership of a farm	3.757	52.84	73.56	63.20
Passing the property on to the next generation	3.541	53.2	68.81	61.01
Community connectedness	3.327	57.94	64	60.97
Peer influence	3.254	56.12	61.9	59.01
Social prestige and life style choice as being a farmer	3.219	48.91	60.07	54.49
Having an intention to expand the farm size (or having a plan to buy a farm)	2.936	43.1	52.3	47.70
Partner's (or owner's) involvement in farming	2.928	22.42	49.91	36.17

Five soil and erosion management practices were presented to the cane farmers in order to examine their acceptance of the LMPs. The most acceptable practice was 'green cane trash blanket retention' with a combined score of 78.54 %, this was followed by 'grassed headland, drains, sediment traps and contour banks as filter strips' with 71.11 %. The other three soil and erosion LMPs attracted less acceptance with 'rotational crop management to harvest' (58.09%), 'strategic or zonal tillage to fallow crops and plant cane' (54.2%), and 'using controlled traffic permanent bed' scoring just 45.49 % acceptance (Table 11)

Table 11 Farmers' consensus and agreement with the relevance of soil and erosion management practices

Soil and erosion management practices (n=5)	Mean score	Consensus (%)	Agreement with '5' (%)	Combined (%)
Green cane trash blanket retention	4.129	73.45	83.62	78.54
Grassed headland, drains, sediment traps and contour bank as filter strips	3.899	64.84	77.37	71.11
Rotational crop management to harvest	3.467	49.93	66.24	58.09
Strategic or zonal tillage of fallow crops and plant cane	3.307	46.5	61.9	54.20
Using controlled traffic permanent bed	3.038	36.74	54.24	45.49

Again eight factors were considered to be more important with over 75% support from the farmers and three of these are economic factors and the other five of these are social and cultural factors (Table 12). Maintaining a long term steady profit is considered the most important factors with the highest combined consensus and agreement score with 80.32% (Table 11). Nine other factors scored above 70% (Table 12). Of interest however are a number of socio-demographic and cultural factors which have rated relatively poorly, such as 'partner's (or owner's) involvement in farming' (34.64%), and 'having an intention to expand the farm size (or having a plan to buy a farm)' (50.28%) (Table 12)

Table 12 Farmers' consensus and agreement with the importance of the factors that influence the above soil and erosion management practices

Factors influencing soil and erosion management practices	Mean score	Consensus (%)	Agreement with '5' (%)	Combined (%)
Maintain a long term steady profit	4.288	73.47	87.16	80.32
Maintaining a quarterly budget, cost control and risk management plan	4.12	74.26	83.2	78.73
Long term involvement with farming	4.039	75.42	81.45	78.44
Focus on controlling own practice	4.046	74.83	81.58	78.21
Self-awareness and openness to current and scientific knowledge	3.983	75.77	80.14	77.96
Maximise profit and minimise labour and overhead costs	4.181	69.3	84.53	76.92
Self-desire to protect natural resources	4.099	70.14	82.52	76.33
Working full-time in the farm	3.943	71.1	79.14	75.12
Access to and availability of cash flow (operation and maintenance funds)	3.993	68.58	79.95	74.27
Freehold ownership of a farm	3.89	65.8	77.25	71.53
Government funding/subsidies for trials of new nutrient and herbicide practices	3.829	63.87	76.05	69.96
Support services from the extension officer and private consultant	3.694	62.11	72.8	67.46
Access to and availability of information and training	3.764	60.22	74.28	67.25
Passing the property on to the next generation	3.545	54.53	68.89	61.71
Uncertainty over selling markets	3.597	53.04	69.96	61.50
Community connectedness	3.304	55.29	63.03	59.16
Peer influence	3.257	55.7	61.8	58.75
Social prestige and life style choice as being a farmer	3.264	52.98	61.83	57.41
Having an intention to expand the farm size (or having a plan to buy a farm)	2.925	48.19	52.37	50.28
Partner's (or owner's) involvement in farming	2.868	21.17	48.1	34.64

Five water and irrigation management practices were examined in this study to understanding farmers' acceptance to practice these LMPs. It found that only two LMPs within this category, irrigation scheduling based on block and soil types (62.08%), and irrigation scheduling plan was supported by the farmers (57.46%) (Table 13). Overall the water and irrigation LMPs were the least supported of the LMP categories.

Table 13 Farmers' consensus and agreement with the relevance of water and irrigation management practices

Water and irrigation management practices (n=5)	Mean score	Consensus (%)	Agreement with '5' (%)	Combined (%)
Irrigation scheduling based on block or soil types	3.621	53.26	70.9	62.08
Irrigation scheduling plan for each crop year	3.542	46.72	68.19	57.46
Using irrigation scheduling tool with some level of automation	2.833	47.93	49.89	48.91
Regular water quality monitoring	2.597	44.06	42.95	43.51
Using low pressure (centre pivot) irrigation system	2.611	36.64	42.27	39.46

Again three factors were considered to be more important with over 75% support from farmers, two of these are economic factors and one is a cultural factor (Table 14). Six other factors scored above 70% and half of these are economic factors and the other half are social and cultural factors. A 'Partner's (or owner's) involvement in farming' was scored poorly (35.35%) and other factors are regarded as average influence with a score between 50% and 70% (Table 14).

Table 14 Farmers' consensus and agreement with the importance of the factors that influence the above water and irrigation management practices

Factors affecting water & irrigation management	Mean score	Consensus (%)	Agreement with '5' (%)	Combined (%)
Maximise profit and minimise labour and overhead costs	4.215	68.42	85.18	76.80
Focus on controlling own practice	4.026	72.48	80.79	76.64
Maintain a long term steady profit	4.183	66.03	84.19	75.11
Maintaining a quarterly budget, cost control and risk management plan	4.02	68.3	80.6	74.45
Self-desire to protect natural resources	4.035	67.54	80.91	74.23
Access to and availability of cash flow (operation and maintenance funds)	3.923	67.75	78.14	72.95
Working full-time in the farm	3.952	66.89	78.81	72.85
Long term involvement with farming	3.952	65.3	78.68	71.99
Self-awareness and openness to current and scientific knowledge	3.869	64.57	77.25	70.91
Support services from the extension officer and private consultant	3.656	61.6	72.03	66.82
Government funding/subsidies for trials of new nutrient and herbicide practices	3.787	56.94	74.62	65.78
Access to and availability of information and training	3.728	57.84	73.41	65.63
Freehold ownership of a farm	3.729	51.3	72.53	61.92
Passing the property on to the next generation	3.488	50.3	67.26	58.78
Community connectedness	3.152	58.03	59.29	58.66
Peer influence	3.095	58.43	57.77	58.10

Factors affecting water & irrigation management	Mean score	Consensus (%)	Agreement with '5' (%)	Combined (%)
Uncertainty over selling markets	3.428	48.12	65.29	56.71
Social prestige and life style choice as being a farmer	3.289	50.64	62.3	56.47
Having an intention to expand the farm size (or having a plan to buy a farm)	3.077	48.46	56.14	52.30
Partner's (or owner's) involvement in farming	2.722	25.98	44.71	35.35

In Table 15 the results of the farmers rating of all of the LMPs considered in the study are shown ordered by the highest combined level of consensus and agreement. The table also includes an identifier to indicate the category of LMP and is colour coded by level of combined consensus and agreement for the LMP by the cane farmers.

Table 15 Farmers consensus and agreement with all LMPs

	Land management practice	Mean score	Consensus (%)	Agreement with '5' (%)	Combined (%)
SE ⁷	Green cane trash blanket retention	4.129	73.45	83.62	78.535
NH ⁸	Timing nutrient/pesticides application with respect to crop stage, irrigation and rainfall	4.126	70.03	83.42	76.725
NH	Application rates of fertiliser/pesticides based on latest industry recommendations	3.947	73.17	79.24	76.205
NH	Soil test fallow block each year	3.942	67.19	78.77	72.98
NH	Variable rate of fertilizer/pesticides between blocks	3.873	66.84	77.49	72.165
SE	Grassed headland, drains, sediment traps and contour bank as filter strips	3.899	64.84	77.37	71.105
NH	Record kept in paddock journal	3.568	59.69	69.95	64.82
WI ⁹	Irrigation scheduling based on block or soil types	3.621	53.26	70.9	62.08
SE	Rotational crop management to harvest	3.467	49.93	66.24	58.085
NH	Using sub-surface or slow-release fertiliser	3.42	50.29	65.55	57.92
WI	Irrigation scheduling plan for each crop year	3.542	46.72	68.19	57.455
SE	Strategic or zonal tillage of fallow crops and plant cane	3.307	46.5	61.9	54.2
WI	Using irrigation scheduling tool with some level of automation	2.833	47.93	49.89	48.91
SE	Using controlled traffic permanent bed	3.038	36.74	54.24	45.49
WI	Regular water quality monitoring	2.597	44.06	42.95	43.505
WI	Using low pressure (centre pivot) irrigation system	2.611	36.64	42.27	39.455

In Table 16 the differences between the combined consensus and agreement scores are shown for each of the factors that may affect the adoption rates of the three categories of LMPs. Highlighted are those differences in scores for the factors affecting the management of the LMP categories which are relatively significant (>5%).

⁷ Soil and erosion

⁸ Nutrients and herbicides

⁹ Water and irrigation

Table 16 Differences in results across farming practices

	Factors affecting management	Nutrient and herbicide (a)	Soil and erosion practices (b)	Water and irrigation (c)	a-b	a-c	b-c
Economic	Maintain a long term steady profit	79.985	80.315	75.11	-0.33	4.875	5.205
Economic	Maximise profit and minimise labour and overhead costs	79.63	76.915	76.8	2.715	2.83	0.115
Cultural	Self-desire to protect natural resources	77.605	76.33	70.91	1.275	6.695	5.42
Economic	Maintaining a quarterly budget, cost control and risk management plan	77.16	78.73	74.45	-1.57	2.71	4.28
Economic	Access to and availability of cash flow (operation and maintenance funds)	76.09	74.265	72.945	1.825	3.145	1.32
Socio-demographic	Long term involvement with farming	75.93	78.435	71.99	-2.505	3.94	6.445
Support services	Access to and availability of information and training	75.85	67.25	65.625	8.6	10.225	1.625
Cultural	Self-awareness and openness to current and scientific knowledge	75.29	77.955	74.225	-2.665	1.065	3.73
Cultural	Focus on controlling own practice	73.895	78.205	76.635	-4.31	-2.74	1.57
Support services	Government funding/subsidies for trials of new nutrient and herbicide practices	73.65	69.96	65.78	3.69	7.87	4.18
Support services	Support services from the extension officer and private consultant	73.36	67.455	66.815	5.905	6.545	0.64
Socio-demographic	Working full-time in the farm	71.105	75.12	72.85	-4.015	-1.745	2.27
Economic	Uncertainty over selling markets	63.78	61.5	56.705	2.28	7.075	4.795
Socio-demographic	Freehold ownership of a farm	63.2	71.525	61.915	-8.325	1.285	9.61
Socio-demographic	Passing the property on to the next generation	61.005	61.71	58.78	-0.705	2.225	2.93
Cultural	Community connectedness	60.97	59.16	58.66	1.81	2.31	0.5
Cultural	Peer influence	59.01	58.75	58.1	0.26	0.91	0.65
Cultural	Social prestige and life style choice as being a farmer	54.49	57.405	56.47	-2.915	-1.98	0.935
Socio-demographic	Having an intention to expand the farm size (or having a plan to buy a farm)	47.7	50.28	52.3	-2.58	-4.6	-2.02
Socio-demographic	Partner's (or owner's) involvement in farming	36.165	34.635	35.345	1.53	0.82	-0.71

The highlighted scores indicated the particular factors which could be reviewed in order to improve the acceptability of LMPs within the specific category.

Further examination of the cane farmers LMP's shows the adoption rate as the percentage of farmers in a region who adopted a particular LMP, the average number of years that the LMP has been utilised, and the percentage of the farm area trialled in the first year of adoption (Table 17). The colour coded rating indicating the acceptability of the LMP by the cane farmers has been maintained (darker green higher acceptability) to show the difference between adoption rates and acceptability of each LMP (Table 17).

Table 17 Percentage of farmers who have adopted the LMPs, Bundaberg and Mackay

LMP Category	Adoption rates by cane farmers 2013	Bundaberg			Mackay		
	Land management practice	Adoption rate %	Ave. Years	% of farm 1st year	Adoption rate %	Ave. Years	% of farm 1st year
NH	Soil test fallow block each year	94	20.89	62.11	92.3	17.90	40.83
SE	Green cane trash blanket retention	88	16.56	90.00	93.8	19.03	76.72
NH	Application rates of fertiliser/pesticides based on latest industry recommendations	94	18.68	91.03	86.2	12.31	80.64
NH	Record kept in paddock journal	90	17.19	86.93	84.6	10.04	96.42
NH	Timing nutrient/pesticides application with respect to crop stage, irrigation and rainfall	98	22.16	90.73	73.8	20.19	87.61
SE	Grassed headland, drains, sediment traps and contour bank as filter strips	80	22.83	88.00	84.6	25.53	82.89
NH	Variable rate of fertilizer/pesticides between blocks	86	19.67	83.38	70.8	15.48	66.78
SE	Strategic or zonal tillage of fallow crops and plant cane	80	15.40	49.55	64.6	10.55	34.88
WI	Irrigation scheduling based on block or soil types	88	18.00	91.00	55.4	14.89	66.33
SE	Rotational crop management to harvest	88	18.68	56.29	53.8	18.39	36.72
SE	Using controlled traffic permanent bed	58	14.50	64.52	72.3	9.19	30.76
NH	Using sub-surface or slow-release fertiliser	62	21.26	84.58	66.2	17.28	74.17
WI	Irrigation scheduling plan for each crop year	64	15.83	85.71	38.5	13.00	63.80
WI	Using irrigation scheduling tool with some level of automation	40	14.74	72.41	40	10.67	63.15
WI	Using low pressure (centre pivot) irrigation system	30	13.93	71.67	47.7	11.00	54.14
WI	Regular water quality monitoring	44	13.77	86.00	30.8	13.00	73.75

Note: Here, SE=Soil and Erosion, WI=Water and Irrigation, and NH=Nutrient and Herbicide

The cane farmers were asked to indicate whether the adoption of the LMPs in each of the LMP categories impacted on the cost, profitability, cost and profitability combined, or neither of these.

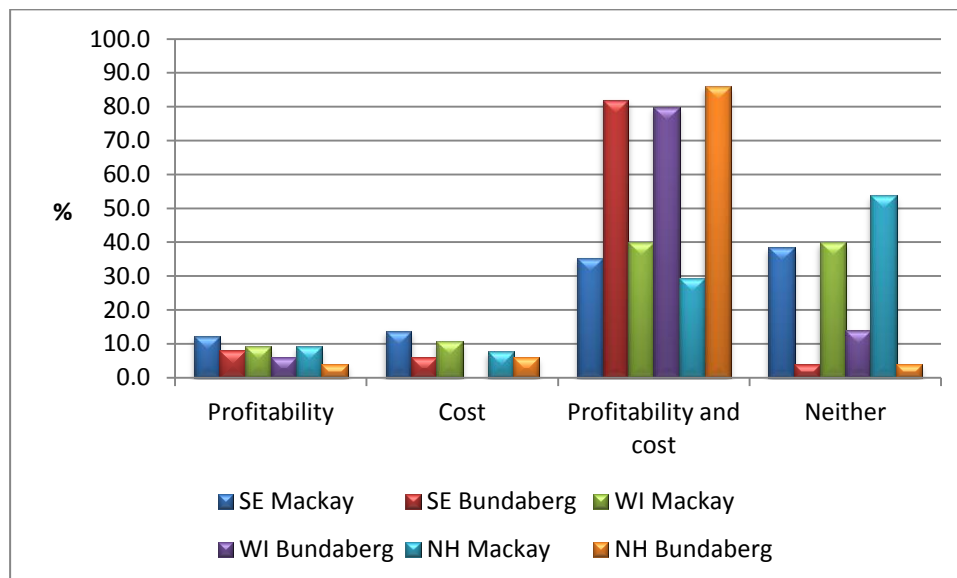


Figure 18 Impact of LMP adoption by LMP category and area

The Bundaberg cane farmers indicated that adoption of LMPs from each of the three categories of LMPs impacted mainly on both profitability and cost. This differs substantially by the Mackay cane farmers who were more likely to indicate that adoption of LMPs did not impact on cost or profit (Figure 18).

7. Discussion

This study assessed the acceptance of three categories of land management practices in cane farming in the Bundaberg and Mackay-Whitsunday regions of Queensland, Australia. This study found that some farmers have been adopting LMPs that have water quality benefits for the last 15 and 18 years in the Bundaberg and the Mackay regions, respectively and in both cases adoption rate is more than 60% (Figure 19). These findings further support those of the GBR Report Card (State of Queensland, 2011).

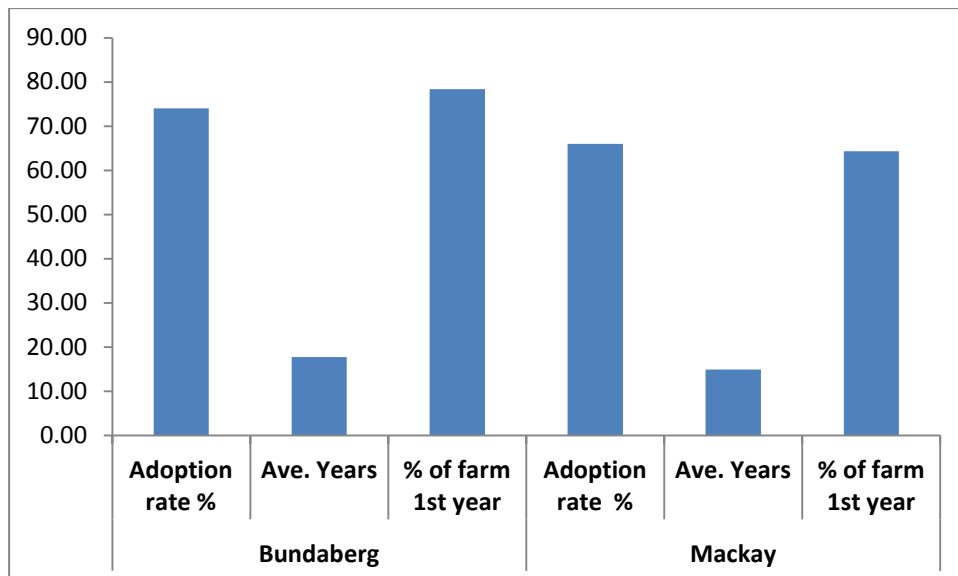


Figure 19 Adoption of LMPs in cane farming that have water quality benefits

Recent assessments, such as the GBR Report Card 2011 point to a significant increase in the adoption of improved land management practices that offer water quality benefits (State of Queensland, 2011). However, the Report Card highlights the ongoing enormity of the task of improving the general health of the GBR, citing in particular the negative impact of natural disasters in 2010-11 on the GBR ecosystem. The Report Card brought attention to positive contributions by Queensland farmers with 17% of graziers and 34% of sugar cane farmers adopting improved water quality LMPs. Figure 20 shows a simple linear regression of the reported adoption rates of Queensland sugar cane farmers, extending the gains from 2008/09 to 2011 to show the Report Card target for adoption rates being met in mid-2013.

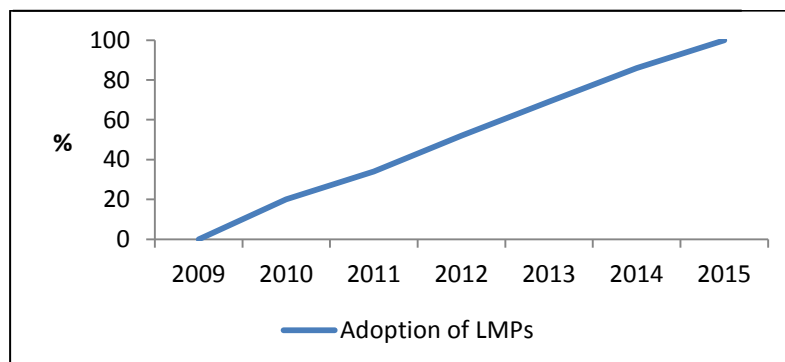


Figure 20 GBR Report Card trend data (Source: State of Queensland, 2011)

Based on the comparison between the 2008-09 baseline data and the reported data in 2010 and 2011, sugar cane growers have shown good progress with 20% of growers in 2010 adopting improved soil, nutrient and chemical management practices and 34% in 2011.

This research which looked at three categories of LMPs, comprising of 16 specific LMPs, found a range of adoption rates for LMPs from a high of 94% for 'soil test fallow block each year' in the Bundaberg region to a low of 30.8% for 'regular water quality monitoring' in the Mackay region. The average adoption rate for Bundaberg and Mackay inclusive of the 16 specific LMPs was 69.98%. In view of the GBR Report Card trend this would appear to be on

target with the expectation for increased adoption of LMPs in order to meet the 2009 LMP adoption target.

The range of adoption for each of the three categories of LMPs is shown in Figure 21 with the highest, average and lowest adoption rate for each category. The nutrient and herbicide (NH) LMPs have the highest average adoption rate followed by soil and erosion (SE) management and the lowest average adoption rate is water and irrigation (WI) management practices.

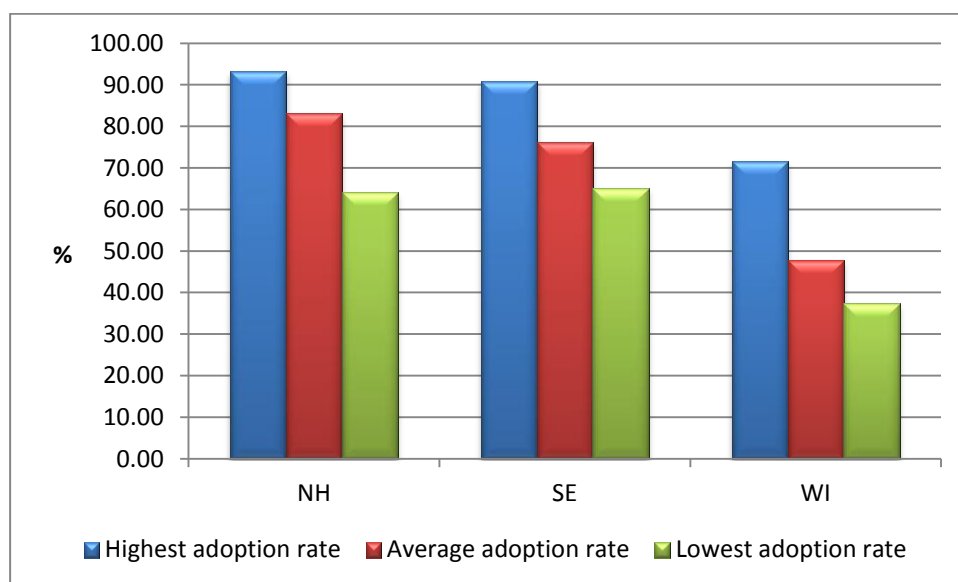


Figure 21 Adoption rates for LMPs

The adoption rates of specific LMPs tend to mirror the consensus and agreement ratings by the cane farmers. This gives a clearer indication of the LMPs to target in order to increase the overall percentage of cane farmers adopting improved practices.

Identification of LMPs is but one part of the equation to increase adoption rates and improve the overall management practices of sugar cane operations. Increasing adoption of any new practice requires an examination of the benefits of the practice not only to the environment but also to the sustainability of the cane farm operation. As evidenced by this research cane farmers in the Bundaberg and Mackay regions are highly experienced (average 30+ years) and efficient in the practice of producing sugar cane and this experience has implications for the introduction of new practices. As identified by the stakeholders the cane growers are not conservative and opposed to innovation however they do expect to see compelling arguments for the adoption of new practices that clearly illustrate environmental benefits and increased farm profitability. For example clarification of the economic benefits for sugar cane farmers transitioning from C to B class and B to A class farming practices is required given the Van Grieken et al. (2009, 2010b) cautionary statements regarding the economic benefits of adopting improved LMPs for sugar cane farmers. This effectively means that in order to assist in the up-take of improved LMPs the business case and the support services for cane farmers needs to be consistent as well as based on transparent research and data.

Importantly for LMP adoption strategies is the recognition that for long term planning to occur that incorporates improved LMPs the sugar cane farmers need to ensure the short to

medium term viability of their farms. An increasing trend in the sugar cane sector is the increased reliance on off-farm income sources as farmers look to hedge the farm viability against fluctuating farm profits and prices. The confidence and capacity for investment in new LMPs by sugar cane farmers would appear related more with higher sugar prices than improved management practices (Greer et al. 2012). In this study the data shows a clear differential between the Bundaberg and Mackay regions in relation to the reliance on off-farm income with Mackay having a higher reliance and in relation to farm profitability with Mackay indicating less profitability than the Bundaberg region. The immediate implications of these findings are the need to ensure close engagement in the development of LMP adoption strategies and the need to contextualise the strategies to the external socio-economic conditions of each GBR catchment region.

The research also identified some clear differences in farm management practices in relation to the contracting out of sugar cane production tasks. The research shows a high percentage of contracting of cane harvesting for the Bundaberg and Mackay regions and although less prevalent a similar level of contracting of tillage and planting activity. However the contracting out of fertilizer and herbicide operations in the Mackay region was well in excess of the contracting for these services in the Bundaberg region. These variations again point to the need to contextualise the approaches to increasing the adoption of improved LMPs by looking more closely at local management practices and localising the adoption strategies.

Identified in this study are the LMPs which attract the least (less than 50%) combined support (consensus and agreement) which are 'using low pressure (centre pivot) irrigation system', 'regular water quality monitoring', 'using controlled traffic permanent bed', and 'using irrigation scheduling tool with some level of automation'. As well as identifying those LMPs that are yet to gain wide spread support from sugar cane growers the study also looked at socio-economic factors, which may influence the adoption of the LMPs.

An examination of the factors influencing the adoption of the water and irrigation LMPs, which feature strongly as the least supported by sugar cane farmers, are economic and cultural factors. The economic factors include the ability to maximise profit and minimise labour and overhead costs, maintaining a long term steady profit, maintaining a quarterly budget, cost control and risk management plan, and access to and availability of cash flow. In addition to these economic factors are cultural factors such as the focus on controlling their own practice, and the level of self-awareness and openness to current and scientific knowledge. In short having the financial planning and means combined with appropriate knowledge and importantly retaining a sense of control over the sugar cane farm are essential factors in assist the adoption of beneficial LMPs.

8. Benefits and application

This study identified the most relevant LMPs in cane farming within the Bundaberg and Mackay regions in Queensland, Australia, which can bring the water quality benefits to the GBR region. This study also identified the extent of adoption (i.e. adoption rate) of the LMPs in these two cane farming regions.

This adoption rate can be informed further to the stakeholders, especially to the governments, about their future investment decision in what LMP(s) they will target on priority basis. The project specifically addressed Reef Rescue Research Priorities 4.3 (socio-economic effects of implementing improved land management practices) and 4.4 (adoption of improved land management practices across Reef catchment). The results directly inform government(s) and stakeholders in relation to the key factors affecting the adoption of LMPs by cane farmers in the Bundaberg and Mackay regions.

This is a pioneer study, which explored and tested both economic and non-economic factors affecting the adoption of LMPs in cane farming in one research framework and this study also found both economic and non-economic (social and cultural) factors are affecting the adoption of LMPs with similar effect to the farmers. Therefore further investment should not only be directed towards subsidies to the practice(s) but should also to the social and cultural factor that affect the rate of adoption. This is one of the key benefits of this study in order to target future adoption policies and strategies. Moreover these factors can be applied and tested to the LMPs of horticulture, grazing, cotton and crops sectors within GBR catchments, can help to safeguard natural resources and ecosystem services within GBR catchments.

Notwithstanding with the above benefits and applications of the study findings, the study applied a combination of fuzzy logic and probability theory based consensus and agreement analysis, which clearly says about the level of farmers' consensus and agreement either with a particular LMP or a factor affecting the adoption of an LMP. This consensus and agreement score is also very easy to comprehend to a lay person to understand the level of importance of each LMP or a factor affecting adoption of an LMP. Consensus and agreement analysis also removes the problem with ordinal data and dispersion analysis. This is the first time, at least in Australia, this methodology has been applied in LMPs' adoption analysis and this can be further used in other agricultural sectors.

9. Conclusions

This study gathered primary data on farmers' and stakeholders' views and perceptions with regard to exploring the LMPs that have water quality benefits. Cane farmers are more interested in nutrient and herbicide management practices (with an average 70% consensus and agreement) compared to soil and erosion management, and water and irrigation management practices (with an average 50% to 60% consensus and agreement) within the Bundaberg and Mackay regions. Within all these three categories: green cane trash blanket retention, grassed headland, drains, sediment traps and contour bank as filter strips, irrigation scheduling based on block and soil types, timing nutrient/pesticides application with respect to crop stage, irrigation and rainfall, soil test fallow block each year, variable rate of fertilizer/pesticides between blocks and application rates of fertiliser/pesticides based on latest industry recommendations, are the most desirable and relevant LMPs to the farmers. All of these LMPs have water quality benefits, specifically at the paddock level.

The study also examined the factors influencing adoption of LMPs that have water quality benefits. The study found nine factors that heavily influence the farmers' decision to adopt an LMP that has water quality benefits. Long-term profitability of the farm is always acted as

a prime factor in the farmer's decision of adoption of any LMP. This study found decisions about adoption LMPs are mostly dependent nine other economic and non-economic factors such as socio-demographic factors, cultural factors and support services and these are:

- access to and availability of cash flow,
- working full-time in the farm,
- self-desire to protect natural resources,
- self-awareness and openness to current and scientific knowledge,
- focus on controlling own practice,
- maintaining a quarterly budget,
- cost control and risk management plan,
- maximise profit and minimise labour and overhead costs, and
- long term involvement with farming.

Half of these factors are economic factors and half of these are socio-cultural factors. Therefore socio-cultural and economic factors are equally influence the farmers in making decision about the adoption of LMP(s).

There are also linkages and barriers among the factors influencing the adoption of LMPs that have water quality benefits and also influence of the factors vary over the type of LMPs. If one makes high importance on one factor such as in economic factor and very little importance of another factor such as in cultural factor, then the rate of adoption may decline or may not be sustainable over a long period of time. For instance, financial incentive works well for the farmers in adopting an LMP but such an incentive package may not be viable over a period of time.

10. Future Directions

- Currently 'B' category LMPs in cane farming are mostly practiced by farmers within the Bundaberg and Mackay regions, and these LMPs can help maintain a standard of water quality in the Reef ecosystem. Therefore, government and stakeholders should promote these LMPs based on the factors of adoption identified in this study.
- Further study on the linkages between social, political and institutional systems that influence the adoption of LMPs that have water quality benefits.
- In-depth qualitative study on the effectiveness of support services for cane farmers wishing to adopt LMPs with water quality benefits.
- Future investment in awareness raising and capacity building.
- Support and promote research that involves multi-stakeholders, including farmers, extension officers, researchers, and decision-makers.

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Appendix 1: Publications

Akbar et al. (2013) Factors affecting the LMPs of cane farming in the wet tropics in Australia that have water quality benefit at the paddock level (submitted to Society and Natural Resources journal).