The role of grazier motivations and risk attitudes in the adoption of grazing best management practices

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Abstract

The onus on landholders in relation to environmental performance is ever increasing. One tool for achieving environmental improvements is the design and promotion of region-specific 'best management practices' (BMPs). These are conservation practices aimed at reducing diffuse source pollution from agricultural lands and thus improving end-of-catchment water quality. A suite of grazing BMPs were developed for the Burdekin Dry Tropics region in a consultative fashion but without explicit consideration of knowledge of adoption processes. It is known from the literature that farmers' goals and risk perceptions in particular influence adoption decisions. This paper utilises the data from an earlier grazier survey to explore to what extent grazier motivations and risk perceptions influence the adoption of BMPs. The results demonstrate clear correlations between both motivations and risk attitudes, and the adoption of recommended BMPs, with specific preferences for different BMPs. We conclude that a sound understanding of landholders' motivations and risk attitudes is required—in a regional, industry and environmental context—to tailor programmes aimed at improving regional environmental performance.

Keywords

conservation practices; adoption, water quality, grazing, Burdekin River catchment, best management practices, risk management, motivations, empirical research, correlations, factor analysis

1. Introduction

The adoption of an innovation by landholders depends principally on whether landholders expect that the practice will help them to achieve their goals, which may include economic, social and environmental goals (Pannell *et al.*, 2006). In their recent review of adoption literature they further conclude that adoption of an innovation, such as a conservation practice, is influenced by the characteristics and circumstances of the landholder, and the characteristics of the practice, especially its relative advantage over existing practices and its trialability.

Trialability refers to the riskiness of the innovation. Deciding whether to adopt the innovation is a risky choice, i.e. the landholder must choose between alternatives whose consequences are not certain. Risk, or uncertainty, modifies the decision process (Musser & Musser, 1984). Risk preferences and perceptions of an innovation's riskiness impact especially on the information acquisition and learning-by-doing phases in the adoption process of farmers (Abadi Ghadim *et al.*, 2005; Abadi Ghadim & Pannell, 1999). Importantly, beliefs about the occurrence of uncertain events and evaluation of potential consequences are entirely personal (Anderson *et al.*, 1988) and adoption decisions consequently reflect the landholder's personal perceptions of risk (Beal, 1996). A review of empirical literature about the influence of risk and uncertainty on the adoption of new technologies in agriculture, found compelling evidence that adoption processes are strongly affected by risk-related issues (Marra *et al.*, 2003). The review specifically pointed to farmers' perceptions about the riskiness of a technology, farmers' attitudes to risk, the role of trialling and learning in adoption decisions, and the option value of delaying adoption.

In addition to their personal dimensions, risk perceptions and risk management strategies in particular are also subject to strong regional, industry and context connotations, (e.g. Flaten *et al.*, 2005; Martin, 1996). However, while the principal elements of risk have received detailed consideration (e.g. Anderson *et al.*, 1988; Hardaker *et al.*, 1997) there appears to be a paucity of empirical studies, which address the practical implications of risk, specifically in relation to the adoption of conservation practices. Such research is critical to assist governments, bureaucrats and people in regional NRM groups with responsibility for policy, program and project design. Regional NRM projects such as the development and promotion of region-specific conservation practices would benefit from an understanding of the specific goals and risk conditions of their farming constituency to ensure maximum adoption.

The objective of this paper is to provide, through an exploratory and descriptive study, empirical insights into landholders' risk perceptions and risk management, their motivations, and how these factors relate to the adoption by landholders of recommended conservation practices. It provides a contribution to the body of empirical literature as well as helping to support the design of effective and efficient regional programmes and initiatives for one region in Australia, the Burdekin Dry Tropics.

2. Background

The Great Barrier Reef (GBR) is the largest coral reef ecosystem in the world, covering an area of 347,800 km^2 and measuring over 2000 km in length along the North-east Australian coast. It was designated a World Heritage Area in 1981 in recognition of its outstanding values (Lucas *et al.*, 1997). The health of the Great Barrier Reef ecosystem is critically influenced by the nutrients, sediments and other pollutants discharged into the GBR lagoon from a large number of adjacent river catchments.

The primary land use in the GBR catchments is cattle grazing across the vast rangelands for beef production. Grazing practices are thought to contribute substantially to the sediments which are discharged by rivers into the GBR lagoon (Brodie *et al*., 2003; Fumas, 2003). Due to its absolute and relatively large size (approximately 134,000 square kilometres), the Burdekin River catchment is a major contributor of sediment to the GBR lagoon.

Because of its intrinsic values but also its large economic value—the contribution of the GBR to the economy was estimated to be $6.1 billion (Access Economics, 2005)—there are substantive public policy efforts underway to improve the water quality entering the GBR lagoon. Among these initiatives is the Coastal Catchment Initiative (CCI), an Australian Government program that seeks to deliver significant targeted reductions in the discharge of water pollutants to agreed 'hotspots'. The GBR lagoon is considered to be a hotspot and the CCI is specifically supporting the development and implementation of a Water Quality Improvement Plan for the Burdekin River catchment (The Australian Government, 2007).

A key strategy of the CCI is to develop 'best management practices' (BMPs). The philosophy is to integrate the human dimension of NRM into a technical or scientific view of how ecosystems need to be managed. Brunner and Clark (1997) list a number of qualities BMPs which ensure they:

- are adapted to different kinds of ecosystems on various scales;
- provide practical guidelines on what to do and why;
- sustain the integrity of particular ecosystems; and,
- represent a working consensus among managers, other practitioners and researchers.

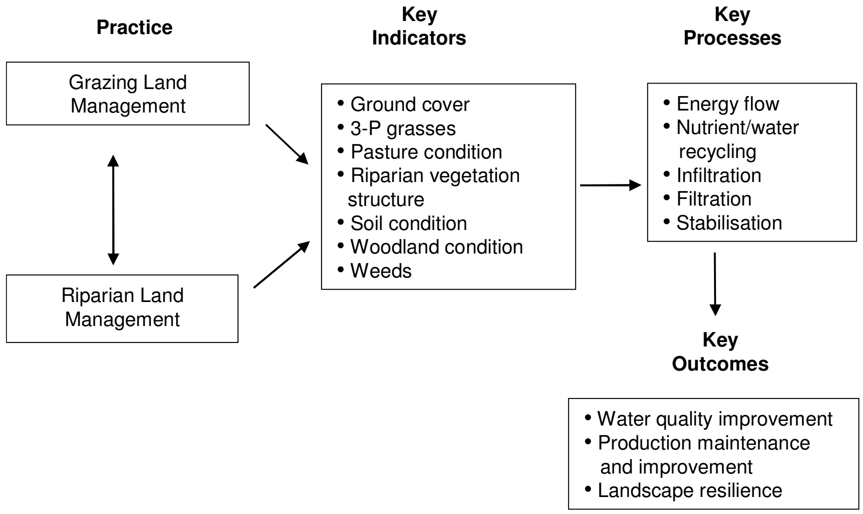
The approach taken in the Burdekin River catchment to develop BMPs has been to consult with landholders on the technical guidelines for best practice and integrate landholder feedback (from a management perspective) into the design of BMPs, specifically for grazing lands and sugar cane areas.

The grazing BMPs for the Burdekin River catchment are framed in the context of ensuring a sustainable, profitable beef industry by managing the rangelands in a manner that maximises water quality and minimises the delivery of nutrients and sediments to aquatic systems (Coughlin *et al*., 2006). The emphasis of grazing BMPs is principally on preventing soil erosion by improving soil and vegetation cover to allow improved water filtration and absorption (Figure 1).

The three main premises behind the recommended land and riparian management principles for grazing lands are (Coughlin et al. 2006):

- maintaining land in good condition with ground cover and pasture cover that will maximise the quality of water from paddock run-off;
- maintaining a relatively open woodland structure to maximise pasture production and ground cover, thereby minimising runoff and maintaining water quality; and,
- treating riparian lands as a unique component of the properties pasture system and managed as a sensitive area with special management requirements.

Figure 1: How riparian and grazing land BMPs help to improve water quality
(Coughlin et al. 2006, p.viii)



While the development of grazing BMPs has been conducted in a consultative fashion by CCI officers with graziers, there has been at best an intrinsic consideration of social and economic dimensions of grazing land management decision making. Specifically the question of how BMPs support graziers' goals and the risk management dimensions of BMPs has received little considered attention.

Production and price risks are key sources of risk specifically in farming environments which are characterised by high variability concerning the biophysical and economic conditions of production, as is the case for grazing properties in the tropical savannas of Northern Australia. In the Burdekin River region, which forms the eastern part of this environment, the coefficient of variation of rainfall is approximately 40% and beef prices have been volatile in the past (Greiner *et al*., 2003).

Related research was conducted by Flaten et al. (2005) who compared risk perceptions and risk management strategies in organic and conventional dairy farmers in Norway. They found that organic farmers perceived themselves to be less risk averse than their conventional colleagues, but both groups regarded institutional risks as primary sources of risk. Meuwissen *et al*. (2001) found that for Dutch livestock farmers, price and production risk were important sources of risk. Reducing the cost of production and insurance were regarded as key strategies to manage risks. Akcaoz and Ozkan (2005) explored the risk perceptions of farmers in a region in Turkey. They found a diversity of risk sources and risk management strategies included diversification, off-farm income, marketing, planning, financing and security. Stordal *et al*. (2007) found for forest owners in eastern Norway that their personal risk perceptions related to risk management strategies, which in turn affected harvesting behaviour and the variability in harvest levels.

3. Material and Methods

Source of data and analytical approach

The data used for this research originated from a survey of landholders in the Burdekin River catchment, which was conducted in late 2006 to explore social and economic dimensions of the implementation of BMPs within a regional and industry context (Greiner *et al*., 2007). The survey included questions about motivations for farming, risk perceptions and risk management, the answers to which have not previously been formally analysed. The objective of including these questions was not to obtain precise risk attitude measures, but to achieve broader categorical ratings of landholders across the catchment area (Fausti & Gillespie, 2006).

This research focused on the 94 grazier respondents. The total sample comprised 114 landholders who managed 222 properties in total, which represented an area coverage of >26% of the Burdekin catchment. Due to the small (sub)sample and the fact that the survey was not conceived primarily as a risk analysis survey, this research is considered exploratory.

The theoretical hypothesis adopted for this exploratory study was that landholders' motives and risk attitudes would be related to the extent to which landholders adopted BMPs and the types of BMPs they chose to adopt.

Basic statistics and multivariate techniques were employed for data analysis and were conducted in STATISTICA (v7.1), which is a comprehensive, integrated data analysis, graphics, and database management system (StatSoft, 2001). It is tailored to applications in market research and social research. It features a wide selection of basic and advanced analytical procedures. Graphics of frequency distributions were generated in Microsoft Excel. The alpha level for testing for statistical significance was set at 0.05 unless stated otherwise.

Principal Component Analysis (PCA) was used to (1) explore a set of variables with a view to identifying the underlying structure and (2) to simplify a large set of variables into a smaller, simpler set of factors for further analysis (Diekhoff, 1992). Factor analysis has been used in previous studies for similar data and outcomes (Flaten *et al*., 2005; Maybery *et al*., 2005). Factor solutions with different numbers of factors were examined before the most representative and parsimonious model was identified (Lien *et al*., 2006).

Correlation analysis (Pearson's R) was performed on this data set to test relationships between variables, in most cases on the factors which were generated from the PCA. Items measured using Likert-type scales were treated as a continuous variables and standard parametric statistical procedures were employed (Lien *et al*., 2007; Meuwissen *et al*., 2001; Patrick & Musser, 1997). Missing data for the correlation analyses were dealt with in a pair-wise fashion to maximise the sample.

Risk assessment model

The risk assessment question in the survey required respondents to rate various sources of risk in terms of the perceived likelihood of occurrence as well as the extent of the (negative) impact if that item did occur. The likelihood rating was either: low, medium or high. The extent of (negative) impact was a five point scale ranging from none (1) to catastrophic (5). From these two ratings a third variable, 'risk assessment', was created ranging from one (very low risk) to five (very high risk). Table 1 shows how the risk assessment scores were calculated.

Table 1: Risk assessment table

	Extent of (negative) impact				
	None	Low	Medium	High	Catastrophic
Likelihood	1	2	3	4	5
Low	very low	very low	low	moderate	high
Medium	very low	low	moderate	high	very high
High	low	moderate	high	very high	very high

Methodological insights provided by previous studies

It has been shown that different methods of data collection on risk attitudes can produce different results (Fausti & Gillespie, 2006) and that "different farming, cultural, and risk environments complicate cross-national comparisons" (Flaten *et al*., 2005). Therefore consistency in phrasing, method of answering, types of questions and wording of questions regrading risk attitude allows for comparable datasets (Fausti & Gillespie, 2006; Pannell *et al*., 2006). Our survey contained similarities to other studies, with regard to one or more of the afore mentioned properties, which allows for comparison in risk attitudes (Akcaoz & Ozkan, 2005; Flaten *et al*., 2005; Maybery *et al*., 2005; Meuwissen *et al*., 2001; Stordal *et al*., 2007).

Meuwissen *et al.* (2001) conducted a mail survey of Dutch farmers (n = 612) which asked three types of questions: (i) Farmers' perceptions of risk (including sources of risk and risk attitude); (ii) Farmers' perceptions of various strategies to manage risk; (iii) Socioeconomic characteristics of the farm and farmer. The types of questions are similar to our study and allow for comparison.

Maybery *et al.* (2005) used a mail survey to investigate the motivations of farmers on the Murray, NSW (n = 552). They used Likert scale to measure response and PCA to reduce listed motivation items into factors. These similarities allow for comparison with our dataset.

Flaten *et al.* (2005) investigated the risk perceptions of conventional (n = 363) and organic (n = 162) Norwegian dairy farmers. The questionnaire contained questions on: (i) farmers' perceptions of risk (risk attitudes and sources of risk); (ii) farmers' perceptions of risk management strategies; (iii) farmers' motivations; (iv) characteristics of the farm and farmer. The use of similar types of question and method of answering allows for comparison.

Akcaoz & Ozkan (2005) identified groups of Turkish farmers (n = 112) who differed with respect to risk attitudes, quantified using Likert scales. They split farmers into three groups based on risk aversion(risk averse, risk seeking and risk neutral) and conducted factor analysis to condense lists of risk sources and risk strategies, yielding separate factors for each group. The similarity in methodology, phrasing and wording of questions allows for comparison.

Stordal *et al.* (2007) contrasted the risk sources and management strategies of forest owners in eastern Norway (n = 303) who do and don't have off-property work. The data was gathered through a mail survey containing 10 sources of risk and 15 risk management strategies which respondents rated on Likert scales. Their data analysis used factor analysis to obtain easily interpretable factor solutions. The similarity in methodology, type and phrasing of questions allows for comparison with our dataset.

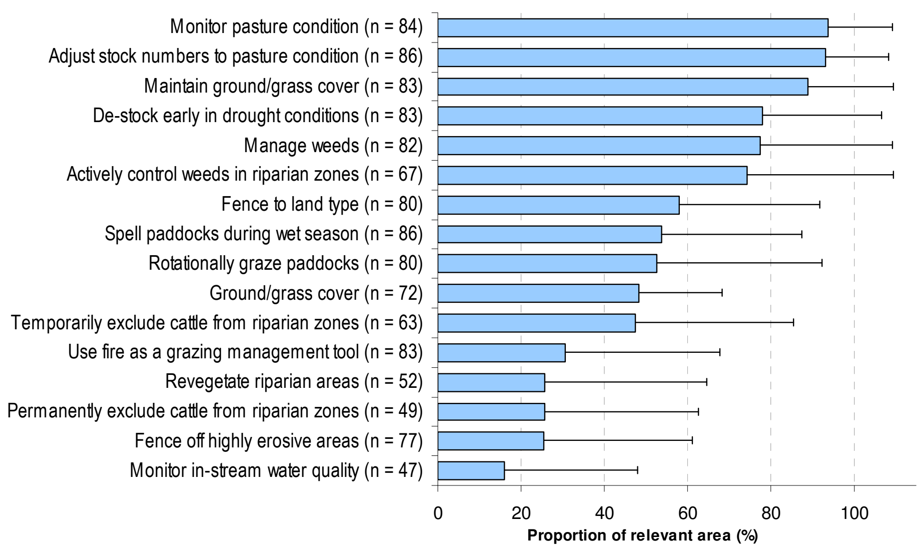
4. Results

The result section is structured into three subsections. Section 4.1 contains a description of the extent to which graziers report the implementation of BMPs. This is the key dependent variable for following analytical steps. Section 4.2 explores graziers' motivations and goals. This includes the testing for any relationship between goals and the extent of implementation of BMPs. Section 4.3 describes and analyses graziers' risk perceptions and management strategies, and explore their relation to the adoption of BMPs. In addition, the relationship between the risk management strategies and (i) grazier goals, (ii) relative risk attitude and (iii) the sources of risk is examined.

4.1. Extent of implementation of Best Management Practices

Graziers across the Burdekin River catchment had implemented BMPs to varying extent (Figure 2). High levels of adoption were evident for 'monitor pasture condition', 'adjust stock numbers to pasture condition', and 'maintain ground/grass cover', with a mean reported coverage of >85% of property area. 'De-stock early in drought conditions ', 'manage weeds' and 'actively control weeds' were implemented on approximately ¾ of property area.

Figure 2: Histogram showing the mean extent of implementation of BMPs by graziers with error bars showing standard deviation.



Items sorted by mean level of implementation.

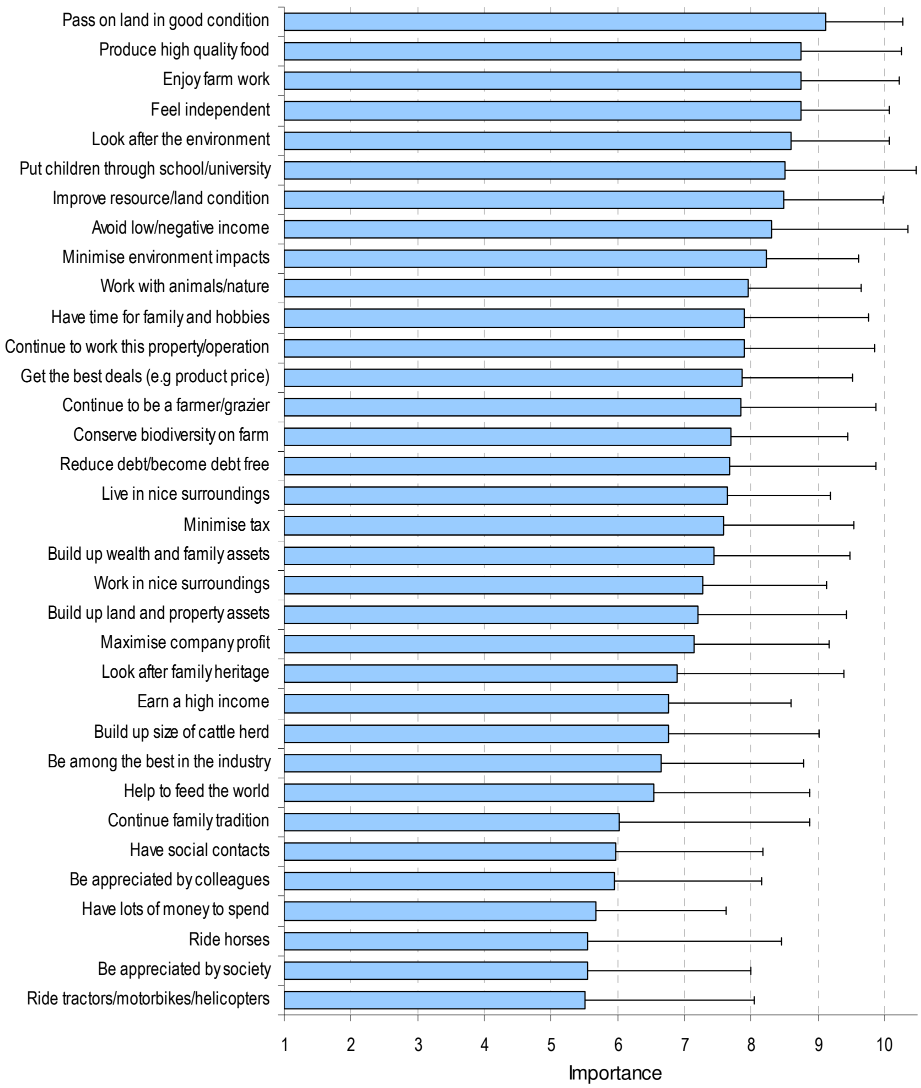
In the survey respondents were able to define their own 'Ground/grass cover' for the item 'Maintain ground cover'

The sample size was considerably reduced for those BMPs that are directly related to river management, including 'monitor in-stream water quality', 'permanently exclude cattle from riparian zones', 'temporarily exclude cattle from riparian zones', 'revegetate riparian areas', and 'actively control weeds in riparian zones'. Adoption levels for these BMPs were low. Also, fencing of highly erosive areas was done, on average, on only small parts of the property area.

4.2. Grazier motivations

Graziers were motivated in conducting their business by a range of things (Figure 3). The grazier survey required respondents to rate the importance of list of 32 motivations[1]. Notably, the five most highly rated items did not include financial motivations but were the items 'pass on land in good condition', 'produce high quality food', 'enjoy farm work', 'feel independent', and 'look after the environment'.

Figure 3: Goals for being a grazier and managing an operation



Items sorted by mean level of importance, error bars show standard deviation; $89 \leq n \leq 92$

Rating scale from 1 = 'not at all important' to 10 = 'extremely important'

[1] Motivation is goal-directed behaviour. Motivations are the forces that account for the arousal, selection, direction, and continuation of behaviour.

The list of motivations was condensed using factor analysis to reduce the number of variables. Similar to Maybery *et al*. (2005) a three factor model was found to provide the best fit and explanation of variance, with approximately 51% of variance explained (Table 2). Unlike Maybery *et al*. (2005), conservation and lifestyle variables did not form two separate factors but were found to load onto the same factor. Because the factors are a combination of motivations we refer to the factors also as "goals". On the basis of item composition, we labelled the factors "conservation and lifestyle goals", "economic/financial goals" and "social goals".

Table 2: Factor loading matrix of the motivation items: three-factor model

Item	Factor 1	Factor 2	Factor 3
Avoid low/negative income	0.162367	**0.530961**	0.073470
Be appreciated by society	0.135539	0.085242	**0.830254**
Be appreciated by colleagues	0.104707	0.073118	**0.770636**
Be among the best in the industry	0.116123	0.135794	**0.618997**
Build up land and property assets	-0.017407	**0.650228**	0.126059
Build up size of cattle herd	0.029280	**0.637860**	0.060725
Build up wealth and family assets	0.062166	**0.766310**	0.161011
Conserve biodiversity on farm	**0.608225**	-0.056967	0.115415
Continue family tradition	0.090013	0.314883	**0.459357**
Earn a high income	0.078652	**0.752547**	0.266203
Enjoy farm work	**0.591883**	0.172120	-0.216310
Feel independent	**0.527741**	0.224264	-0.117183
Get the best deals	0.319683	**0.629620**	-0.055329
Have lots of money to spend	0.021359	**0.742949**	0.194015
Have social contacts	0.148837	0.295449	**0.507630**
Have time for family and hobbies	**0.705989**	0.316550	0.256165
Help to feed the world	0.379332	0.267129	**0.491203**
Improve resource/land condition	**0.839270**	0.018798	0.213502
Live in nice surroundings	**0.454714**	0.217327	0.081775
Look after the environment	**0.879807**	-0.101027	0.122860
Look after family heritage	0.168818	0.325113	**0.559775**
Maximise company profit	0.087378	**0.730520**	0.259273
Minimise environmental impacts	**0.761905**	0.165493	0.200129
Minimise tax	0.245410	**0.594344**	-0.050736
Pass on land in good condition	**0.855577**	0.073796	0.062673
Produce high quality food	**0.602684**	0.357819	-0.215900
Put children through school/university	0.351877	0.190617	**0.453718**
Reduce debt	0.225571	**0.591086**	-0.219226
Work with animals/nature	**0.760868**	0.137415	0.045249
Variance Explained (%)	20.9	18.3	12.0

Varimax orthogonal rotation was applied and missing data was substituted with mean values.

Six items from the questionnaire were removed due to not significantly loading onto any of the factors (loading <0.4) or they were complex (loading on multiple factors).

Factor scores ≥ 0.4 in bold.

Factor 1: Conservation and lifestyle goals

Factor 2: Economic/financial goals

Factor 3: Social goals

Graziers who tended to scored high on the conservation and lifestyle goals were driven by a stewardship and custodianship ethic ('look after the environment'), combined with enjoyment of their work and lifestyle. Graziers who tended to score highly on the economic/financial goal were driven by wanting to generate income and assets. Graziers who scored highly on the social goal perceived themselves as social custodians and displayed a strong desire to be appreciated and acknowledged by society and their peers.

Among the economic motivation items 'avoiding low/negative income' received the highest rating (Figure 3) but had a medium loading on the economic/financial goal (Table 2).

Pearson's correlations were conducted between respondents' goals and the extent to which they had implemented BMPs, to explore whether there was a detectable relationship (Table 3).

Table 3: Correlation matrix (Pearson's R) between motivation factors and implementation of grazing BMPs

	Motivation factors		
Best Management Practices	Conservation & lifestyle	Economic/ financial	Social
Maintain ground/grass cover	**.3127***** N=81	.0456 N=77	.1541 N=79
Monitor pasture	**.2947***** N=83	-.0989 N=79	.1182 N=80
Fence to land type	**.3107***** N=79	-.0406 N=76	-.0308 N=77
Adjust stock numbers to pasture condition	.0206 N=84	-.0695 N=80	-.0613 N=81
De-stock early in drought conditions	**.2580**** N=82	-.0935 N=78	-.0158 N=79
Spell pastures during wet season	**.2185**** N=84	-.0395 N=80	-.0091 N=81
Rotationally graze paddocks	**.2814**** N=79	-.1581 N=76	-.0891 N=76
Use fire as a grazing management tool	-.1314 N=82	-.1216 N=80	-.0765 N=80
Fence off highly erosive areas	.1996* N=77	.0731 N=74	.0236 N=74
Manage weeds	-.0842 N=80	-.0272 N=76	.1116 N=76
Ground/Grass cover	-.0264 N=72	-.0508 N=68	-.1121 N=69
Permanent exclusion of cattle from riparian zones	.1902 N=49	.0249 N=48	-0.2652* N=49
Temporary exclusion of cattle from riparian zones	**.2486**** N=63	.1194 N=59	.0714 N=61
Revegetate riparian zones	.2370* N=52	.0024 N=50	-.1032 N=51
Actively control weeds	-.0649 N=67	-.0194 N=63	.1357 N=63
In-stream monitoring	.1379 N=47	.2679* N=45	.1054 N=46

*** marked correlations are highly significant at $p < 0.01$

** marked correlations are significant at $p < 0.05$

* marked correlations are significant at $p < 0.10$

Pair wise deletion of data was used to maximise sample size. N is shown due to varying number of data points.

'Conservation and lifestyle' was the only goal for which correlations could be established. The BMPs labelled 'maintain ground/grass cover', 'monitor pasture' and 'fence to land type' correlated with the conservation and lifestyle goal at p<0.01. Statistically significant correlations at the p<0.05 level were also found with 'de-stock early in drought conditions', 'spell pastures during wet season' and 'rotationally graze paddocks'.

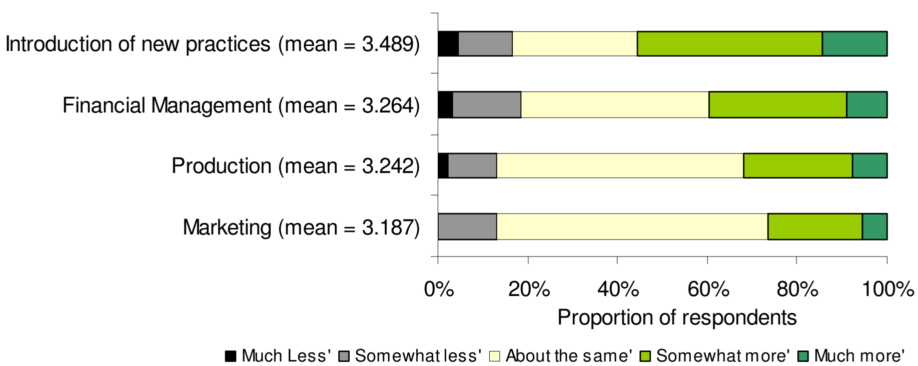
4.3. Risk perception and risk management

The investigation of risk included three aspects. Respondents provided a relative risk rating of themselves in comparison to other graziers. They also provided a risk assessment for numerous sources of risk by rating the likelihood they would occur and the impact of that occurrence. They rated the importance of a diversity of risk management activities. The results of these ratings are described, analysed and then tested for influence on the adoption of BMPs.

Relative risk attitude

Adapting the approach taken by Meuwissen *et al.* (2001), respondents were asked to rate their risk attitude relative to other graziers. Meuwissen *et al.* (2001) call this the "relative risk attitude" as it captures a grazier's perception of his or her risk attitude. Figure 4 shows how respondents perceived their risk attitude in relation to various aspects of grazing management. In general terms, respondents rated themselves as taking about the same to slightly more risks than other graziers. The exception was 'introduction of new practices', where a majority of respondents saw themselves as taking more risks, i.e. being early adopters of new practices.

Figure 4: Relative risk perception of respondents on various aspects of the grazing operation



The survey question was: "When you compare yourself to other operators in your industry, would you say that you are willing to take more or less risks with respect to the following aspects of your operation?" Answers were on a 5-point Likert scale with 1=much less to 5=much more.

Correlation analysis was conducted between the relative risk attitude of respondents and the extent to which they had implemented BMPs (Table 4). The results shows that graziers who perceived themselves as risk takers, or early adopters, in relation to the introduction of new grazing practices showed higher levels of implementation of rotational grazing, adjustment of stock number to pasture condition, and early de-stocking in preparation for drought.

Table 4: Correlation between the self perceived risk taking of graziers with respect to the introduction of new practices and the level of implementation of BMPs

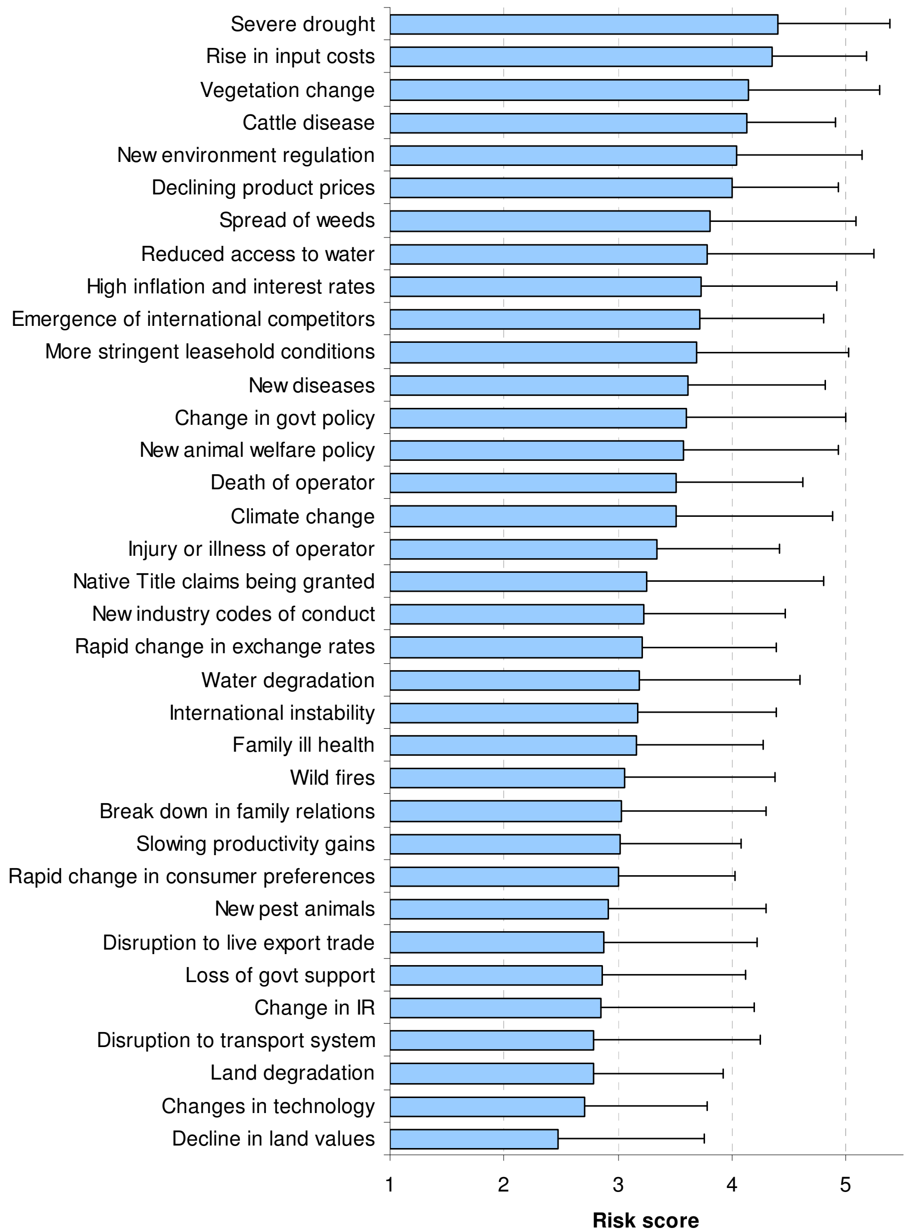
Best Management Practices	Relative risk attitude of 'Introduction of new practices'
Maintain grass/ground cover	.1356 N=81
Monitor pasture condition regularly	.1126 N=83
Fence to land type	-.0469 N=79
Adjust stock numbers to pasture condition	**.2609**** N=84
De-stock early in drought conditions	**.2699**** N=82
Spell paddocks during wet season	.1678 N=84
Rotationally graze paddocks	**.3048***** N=79
Use fire as a grazing management tool	-.0176 N=82
Fence off highly erosive areas for conservation	-.2220* N=76
Manage weeds	-.1317 N=80
Permanent exclusion of cattle from riparian zones	.0120 N=48
Temporary exclusion of cattle from riparian zones	.1101 N=62
Revegetate riparian areas	-.0161 N=51
Actively control weeds along creeks and rivers	-.0905 N=66
Monitor in-stream water quality	.0619 N=46

Sources of Risk

Respondents were asked to provide an assessment of the likelihood and severity of potential impact of a diversity of sources of risk. These included climatic, market, institutional, production, environmental and personal health risks (Hardaker *et al*., 1997), some of which were generic and other sources tailored to regional and industry conditions. Using the risk assessment metric outlined in Table 1, risk assessment scores were calculated for each risk source, with values ranging from 1=low risk to 5=high risk.

Figure 5 shows the mean values obtained for each source of risk, and the standard deviations. The single most important source of risk for graziers in the Burdekin River catchment was ‘severe drought’. This was followed by ‘rise in input costs’, ‘vegetation change’, ‘cattle disease’, ‘new environmental regulation’ and ‘declining product prices’, which all received a mean rating of ‘very high risk’. This shows that a diversity of risk sources, including climatic, economic, environmental and institutional were relevant to graziers in the Burdekin River catchment.

Figure 5: Risk assessment for sources of risk to the viability of the grazing operations



Items are sorted by mean and error bars show the standard deviation.

Risk assessment score calculated using risk assessment model (Table 1).

A factor analysis was performed on the sources of risk items. Principal component analysis did not yield factors with explanatory power. Therefore the items were manually ascribed into 'categories' through thematic attribution. Table 5 shows the categories and illustrates how sources of risk items were assigned. Strictly speaking, 'severe drought' is a production risk. However, due to its stand out risk rating it was given the status of a one-item category. No correlations between the risk assessment of 'severe drought' and either farm debt or farm equity were found.

The internal reliabilities of these categories were calculated using Cronbach's alpha and are shown in Table 5. All categories achieved values >0.7, as recommended by De Vaus (2002, p.184).

Table 5: Assignment of sources of risk items into categories

	Sources of risk				
Risk items	Family Health	Markets/ prices	Legislation	Production	Severe Drought
Break down in family relations	X				
Cattle disease		X			
Change in government policy			X		
Change in IR			X		
Changes in technology				X	
Climate change				X	
Death of operator	X				
Declining product prices		X			
Decline in land values		X			
Disruption to live export trade		X			
Disruption to transport system		X			
Emergence of international competitors		X			
Family ill health	X				
High inflation and interest rates		X			
Injury or illness of operator	X				
Land degradation				X	
Loss of government support		X			
International instability		X			
More stringent leasehold conditions			X		
Native Title claims being granted			X		
New diseases				X	
New environment regulation			X		
New pest animals				X	
New industry codes of conduct			X		
New animal welfare policy			X		
Rise in input costs		X			
Rapid change in consumer preferences				X	
Rapid change in exchange rates		X			
Reduced access to water			X		
Slowing productivity gains				X	
Spread of weeds				X	
Severe drought					X
Vegetation change				X	
Water degradation				X	
Wild fires				X	
Cronbach's alpha	0.7311	0.851	0.7824	0.7699	1

Categories have been colour coded for ease of identifying items assigned to each factor.

A correlation matrix was established, using Pearson's R, between the sources-of-risk categories and the relative risk perception of respondents. No significant correlations were found.

A further correlation matrix was established, using Pearson's R, between the sources-of-risk categories and the implementation of BMPs. The results are shown in Table 6.

There were few correlations of significance at the $p<0.05$ level. There was one significant negative correlation between 'severe drought' and 'permanent exclusion of cattle from riparian zones' indicating that graziers who are more concerned about drought were specifically averse to permanently excluding cattle from riparian zones for the benefit of water quality. 'Temporary exclusion of cattle from riparian zones' was positively correlated to price/market risk. 'Fencing off highly erosive areas' was positively correlated to the institutional and market/price risk categories.

Table 6: Correlation matrix (Pearson's R) between sources of risk factors and proportion of land on which BMPs are implemented.

	Sources of risk				
Best Management Practices	Family health	Markets / prices	Institutional	Production	Severe drought
Maintain ground/grass cover	.1406 N=76	.1064 N=68	.0189 N=71	-.0617 N=71	.0595 N=81
Monitor pasture condition	-.0734 N=78	.0234 N=69	-.0399 N=72	-.0948 N=72	-.0461 N=82
Fence to land type	-.1747 N=74	.0456 N=67	.0604 N=69	-.1276 N=69	.0185 N=77
Adjust stock numbers to pasture condition	.0562 N=79	.0770 N=70	-.0549 N=73	-.1649 N=73	-.2060* N=84
De-stock early in drought conditions	.0155 N=77	.0030 N=70	-.0089 N=71	.0368 N=71	-.0773 N=81
Spell pastures during wet season	-.0453 N=78	.1837 N=70	.0321 N=73	.0080 N=73	-.0217 N=84
Rotationally graze paddocks	-.0821 N=74	.0823 N=66	-.0492 N=69	.0726 N=68	-.1295 N=79
Use fire as a grazing management tool	.0704 N=76	.0513 N=69	.0883 N=71	-.0059 N=71	.1624 N=81
Fence off highly erosive areas	.0815 N=71	**.2455**** N=65	**.2677**** N=67	.2131* N=66	-.0173 N=76
Manage weeds	-.0423 N=75	.0343 N=65	.0460 N=69	-.1016 N=69	-.0265 N=79
Permanent exclusion of cattle from riparian zones	.1598 N=45	.0422 N=40	-.0491 N=41	.0417 N=40	**-.3302**** N=48
Temporary exclusion of cattle from riparian zones	.2219* N=59	**.3127**** N=53	.1282 N=55	.0759 N=55	-.0550 N=61
Revegetate riparian zones	-.0298 N=48	.2053 N=42	.2846* N=44	.1907 N=44	.0779 N=51
Actively control weeds	-.0916 N=62	.0893 N=53	-.0206 N=56	-.0630 N=57	-.1857 N=64
In-stream monitoring	-.0840 N=44	.0888 N=39	.2578 N=40	.0094 N=40	.2276 N=46
Target ground/grass cover (%)	-.0203 N=69	.0296 N=60	-.1867 N=64	.1317 N=64	-.0629 N=69

*** marked correlations are highly significant at $p < 0.01$

** marked correlations are significant at $p < 0.05$

* marked correlations are significant at $p < 0.10$

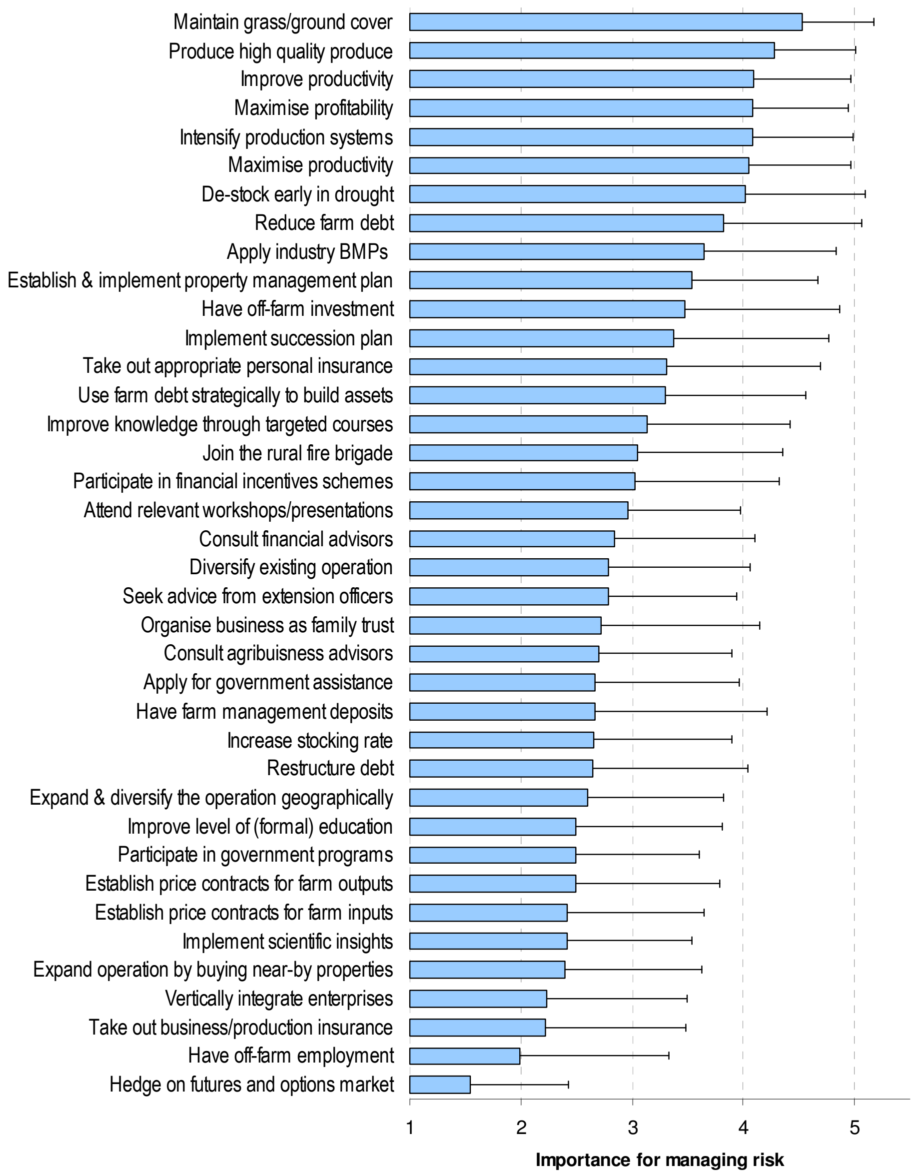
Pair wise deletion of data was used to maximise sample size.

Risk management

Graziers were asked to rate the importance of a series of risk management strategies and activities in managing all aspects of risk in their operation. The activities included production, marketing, financial, structural, educational and integrated responses to risk (Sonka & Patrick, 1982). The rating scale was from 1 = not at all important to 5 = extremely important. Figure 6 shows the resulting means and standard deviation for each activity.

Maintaining grass cover was seen by respondents as the most important risk management strategy. This reflects the growing realisation that graziers are grass farmers (Kraatz *et al.*, 2006). Producing high quality beef was also seen as a key strategy as were measures to improve productivity and profitability, and the intensification of production systems. At the other end of the spectrum, expansion, vertical integration, insurance, off-farm employment and hedging were not generally regarded as important risk management strategies.

Figure 6: Histogram showing the mean importance of activities for managing risk.



Items sorted by mean importance with error bars showing the standard deviation.

Items rated from: 1=not at all important to 5=extremely important

A principal components analysis was conducted to explore the underlying structure of the risk management activities[2]. An eight factor model was chosen as it offered the best explanatory

[2] Seven risk management activities were removed due to low factor loadings (i.e. < 0.4) and/or they were complex (loading on multiple factors). Three complex risk management activities have been included where the highest loading has determined the factor the activity is assigned to. These have been included due to the large difference between loadings.

power. This provided an indication of the complexity of risk management. The factor loading matrix for the eight factor model (Table 7) shows each factor represented by a risk management strategy. This eight-factor model explained approximately 66 per cent of the variance.

Table 7: Factor loading matrix of risk management activities: eight-factor model

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Apply for government assistance when available	0.1212	0.0097	0.0965	0.1725	0.0949	0.3587	**0.6968**	0.0538
Attend relevant workshops/presentations	-0.0703	**0.4099**	-0.1329	0.2112	-0.0243	**0.4616**	0.3186	0.2663
Consult financial advisors	0.0866	0.1274	0.1085	0.0399	0.1027	**0.8764**	0.0756	0.0797
Consult agribuisness advisors	0.1679	0.1723	0.1686	0.1241	-0.0558	**0.8327**	0.0818	0.0071
De-stock early in drought	0.0233	0.2113	0.0898	-0.1652	0.1449	0.1419	-0.0122	**0.6971**
Diversify existing operation into multiple enterprises	-0.0297	0.2824	0.1672	**0.4515**	0.2950	0.2084	0.0481	-0.0147
Establish and implement property management plan	0.1292	0.0757	0.2496	0.1295	-0.0297	0.0206	-0.0035	**0.8067**
Establish price contracts for farm inputs	0.0030	0.0348	**0.9012**	0.0857	0.0745	0.1565	0.0855	0.1512
Establish price contracts for farm outputs	0.1484	0.0516	**0.8592**	0.1006	0.0440	0.1169	0.1012	0.1128
Expand operation by buying near-by properties	0.3139	0.0239	0.2756	**0.6812**	0.1098	-0.0435	0.1925	-0.0590
Expand and diversify the operation geographically	0.1401	0.1199	0.1657	**0.8025**	0.1199	0.0366	0.1114	-0.0041
Hedge on futures and options market	0.0762	0.3480	**0.6635**	0.2501	-0.0610	-0.0566	-0.2028	0.0567
Implement scientific insights	-0.0083	**0.6984**	0.1949	0.2102	0.3204	0.1364	-0.1723	0.0448
Implement succession plan	0.2826	0.2253	-0.0966	**0.4228**	0.0331	0.3487	-0.3294	0.2200
Improve productivity	**0.6843**	0.1860	0.0048	0.1868	0.0481	0.3503	-0.1480	0.0888
Improve level of (formal) education	0.0220	**0.7714**	0.1388	0.0107	0.1140	0.1715	0.0252	0.0320
Improve knowledge through targeted courses	0.1324	**0.7185**	0.0165	0.2382	-0.1124	0.1374	0.1570	0.3746
Increase stocking rate	**0.4081**	0.2498	0.2690	0.3278	0.0349	-0.1145	0.3901	-0.2168
Have off-farm employment	-0.0132	0.0949	0.2770	-0.2824	**0.5961**	-0.1685	0.2836	0.1205
Have off-farm investment	-0.0800	0.2306	-0.0885	0.2331	**0.6890**	0.0326	0.1404	0.0675
Maintain grass/ground cover	0.1376	0.2071	0.0694	-0.0665	0.3142	0.0470	-0.0838	**0.4160**
Maximise profitability	**0.6033**	0.2323	0.0559	0.1452	0.0058	0.0930	0.2155	0.0058
Maximise productivity	**0.7849**	0.0297	0.0621	0.1942	-0.1438	0.0717	0.1304	0.1212
Participate in financial incentives schemes	-0.0094	0.2225	0.2664	0.1840	0.1940	0.0501	**0.4367**	**0.5201**
Produce high quality produce	**0.6011**	-0.2157	0.2589	-0.0299	0.2624	0.0375	-0.1658	0.2284
Reduce farm debt	**0.5321**	0.0836	0.1215	0.1969	0.3671	0.2705	0.0635	-0.2125
Seek advice from extension officers	0.3501	**0.5868**	0.0896	0.0313	0.0355	0.1864	0.1439	0.0961
Take out buisness/production insurance	0.1871	-0.0241	0.2752	0.3709	0.3962	**0.4371**	-0.0974	-0.0302
Take out appropriate personal insurance	0.2376	-0.0514	0.0357	0.2158	**0.5593**	0.3203	-0.2220	0.1013
Use farm debt strategically to build assets	0.1017	0.1846	-0.0959	**0.7410**	-0.0336	0.2885	-0.0307	0.1765
Vertically integrate enterprises	0.0723	0.0871	**0.4062**	**0.6692**	-0.0115	0.1255	0.0374	0.0023
Variance Explained (%)	9.1	9.3	9.4	11.0	6.3	9.0	4.9	6.9

Varimax orthogonal rotation applied and missing data substituted with mean values.

Factor loadings in bold ≥ 0.4.

Factor 1: Productivity maximisation

Factor 2: Human capacity & knowledge

Factor 3: Price risk management

Factor 4: Expansion & diversification

Factor 5: Family income diversification & insurance

Factor 6: Expert advice

Factor 7: Government assistance

Factor 8: Best management practices

Pearson's correlations were conducted at the factor level between the motivational factors and risk management strategies, as shown in Table 8. This was performed to explore whether motivational aspects are related to preferred risk management strategies.

Table 8: Correlation matrix (Pearson's R) between motivation factors and the risk management strategies

	Motivation factors		
Risk Management Strategy	Conservation and lifestyle	Economic/ financial	Social
Expansion & diversification	**.2286****	**.3986*****	**.3785*****
Best management practice	**.4673*****	.0230	.1883*
Business innovation	**.3877*****	**.3203*****	**.3099*****
Productivity maximisation	**.3327*****	**.5916*****	**.3327*****
Price risk management	**.2656****	**.3751*****	.2089*
Farm financial management	**.2969*****	**.2758****	.0894
Government assistance	**.3410*****	**.3699*****	**.2716****
Human capacity & knowledge	.1654	.0899	.2119*

*** marked correlations are highly significant at $p < 0.01$

** marked correlations are significant at $p < 0.05$

* marked correlations are significant at $p < 0.10$

Pair wise deletion of data was used to maximise sample size. $77 \leq n \leq 90$

The results showed that graziers with higher levels of motivation—irrespective of their type of motivation—tended to rate diversity of risk management strategies as important, compared to respondents with lower levels of motivation. The importance of expansion & diversification, business innovation, government assistance, productivity maximisation, and consultation of advisors were preferred risk management strategies of highly motivated respondents, irrespective of type of motivation. Graziers motivated by conservation and lifestyle goals particularly embraced BMPs. Graziers with high social motivation tended to rate human capacity & knowledge somewhat more important as a risk management strategy (p<0.1). There was no relationship between BMPs as a risk management strategy and economic/financial motivations.

A correlation matrix, using Pearson's R, between risk management strategies and relative risk attitudes of graziers is shown in Table 9.

Table 9: Correlation matrix (Pearson's R) between risk management strategies and risk taking perception of graziers compared to their peers

	Relative risk attitude			
Risk Management Strategy	Production	Marketing	Financial Management	Introduction of new practices
Productivity maximisation	**.2552****	**.2449****	.1324	**.2575****
Human capacity & knowledge	.0462	.1044	.0474	**.3182*****
Price risk management	.0831	.1018	.0666	.0378
Expansion & diversification	**.3454*****	**.2662****	**.5361*****	**.4288*****
Family income diversification & insurance	-.1450	-.0226	-.1357	.0458
Expert advice	.1650	**.2342****	.2039*	**.3098*****
Governmental assistance	**.2757*****	.0677	-.0021	.0748
Best management practice	-.0295	-.0073	.0179	.1330

*** marked correlations are highly significant at $p < 0.01$

** marked correlations are significant at $p < 0.05$

* marked correlations are significant at $p < 0.10$

Pair wise deletion of data was used to maximise sample size. $80 \leq n \leq 90$;

Productivity maximisation as a risk management strategy was generally more important to respondents who saw themselves as risk takers in any category, except financial and management matters. Improving human capacity and knowledge was important to respondents who perceived themselves as risk takers and early adopters of BMPs. They also saw expert advice as important, as did respondents who saw themselves as risk takers in marketing. Enterprise expansion & diversification was statistically significantly correlated to all aspects of risk taking—although the various activities that form part of the strategy rated comparatively lowly in importance (Figure 6). Government assistance was specifically important to respondents who saw themselves as risk takers in production.

A correlation matrix (Pearson's r) between sources of risk factors and risk management strategies is shown in Table 10.

Table 10: Correlation matrix (Pearson's R) between sources of risk and risk management strategies

	Source of Risk				
Risk Management Strategy	Family Health	Markets/ prices	Institutional	Production	Severe drought
Productivity maximisation	**.3004*** **N=78	**.4714*** **N=69	**.4212*** **N=75	**.2786** **N=73	**.7397*** **N=86
Human capacity & knowledge	.1060 N=80	.1400 N=72	.0131 N=75	.1793 N=75	**.2844*** **N=86
Price risk management	.1787 N=81	**.3743*** **N=72	**.2398** **N=77	.1930* N=77	**.2361** **N=87
Expansion & diversification	.0769 N=78	.1858 N=67	**.2618** **N=74	-.0208 N=72	**.4301*** **N=81
Income diversification & insurance	.1448 N=81	.2259* N=71	.1407 N=76	.0588 N=76	**.3481*** **N=89
Expert advice	.2033* N=81	.0874 N=71	.1335 N=76	.0381 N=76	**.3925*** **N=87
Governmental assistance	**.3207*** **N=82	**.3555*** **N=72	.1771 N=77	.2172* N=77	**.2731** **N=88
Best management practice	.1355 N=82	**.3286*** **N=72	.1684 N=77	.1825 N=77	.0722 N=88

*** marked correlations are highly significant at $p < 0.01$

** marked correlations are significant at $p < 0.05$

* marked correlations are significant at $p < 0.10$

Pair wise deletion of data was used to maximise sample size. 69 <= n <= 88

Productivity maximisation was the only RMS which correlates with all sources of risk. Those respondents most concerned with severe drought as a source of risk look towards all risk management strategies except BMPs. BMPs, as a risk management strategy, were only correlated to markets & prices as a source of risk. Government assistance was seen as important by those who are concerned about family health and markets/prices. Expansion & diversification tended to seen as important to those who regarded institutional sources as a high risk.

A correlation matrix (Pearson's r) between risk management strategies and the extent of implementation of grazing BMPs is shown in Table 11.

Table 11: Correlation matrix (Pearson's r) between risk management strategies and level of implementation of grazing BMPs

	Risk management strategies							
Best management practice	Productivity maximisation	Human capacity & knowledge	Price risk management	Expansion & diversification	Family income diversification & insurance	Expert advice	Governmental assistance	Best management practice
Maintain ground/grass cover	.0964 N=79	.1041 N=80	.0758 N=83	.1020 N=76	.0103 N=82	.0464 N=81	.1160 N=82	**.3267*** N=83**
Monitor pasture condition	.0032 N=81	.0224 N=82	.0463 N=83	.0659 N=78	-.0157 N=83	.1621 N=83	.0278 N=84	**.2565** N=84**
Fence to land type	-.0472 N=76	.0374 N=78	.1152 N=79	.0714 N=74	.1005 N=79	.0254 N=79	-.1870* N=80	.1416 N=80
Adjust stock numbers to pasture condition	-.1070 N=82	.0259 N=83	-.0239 N=85	-.0199 N=79	.0061 N=85	.0150 N=84	-.0730 N=85	.1471 N=86
De-stock early in drought conditions	.1002 N=80	.1891* N=82	.0245 N=82	.0772 N=77	.0770 N=82	**.2458** N=82**	-.0299 N=83	**.4836*** N=83**
Spell pastures during wet season	.1551 N=82	**.3178*** N=83**	**.3178*** N=85**	.2074* N=78	.0405 N=85	.1247 N=84	.0393 N=85	**.2677** N=86**
Rotationally graze paddocks	-.0234 N=78	**.2988*** N=78**	.1772 N=79	.1338 N=75	-.0288 N=79	.1058 N=80	.0532 N=80	**.3186*** N=80**
Use fire as a grazing management tool	.1544 N=80	-.0873 N=81	.1590 N=82	**.2383** N=76**	-.0731 N=82	-.0533 N=83	**-.2565** N=83**	-.0861 N=83
Fence off highly erosive areas	-.0308 N=75	.0662 N=75	**.2599** N=76**	.1054 N=71	.2026* N=76	-.0691 N=77	.0016 N=77	**.3461*** N=77**
Manage weeds	-.0280 N=77	-.1398 N=78	-.1571 N=81	-.0915 N=75	-.0042 N=81	-.1584 N=81	-.1185 N=81	.0255 N=82
Permanent exclusion of cattle from riparian zones	-.2749* N=48	.0558 N=47	**.2835** N=49**	-.0436 N=46	.0445 N=49	-.0813 N=49	-.1152 N=49	**.3105** N=49**
Temporary exclusion of cattle from riparian zones	.0068 N=60	.2129 N=61	.2145* N=63	.2141 N=58	.1820 N=62	.0827 N=62	.1121 N=63	**.3825*** N=63**
Revegetate riparian zones	.0608 N=51	.2258 N=50	.2375* N=52	.1158 N=48	.1203 N=52	.0430 N=52	-.0827 N=52	**.3066** N=52**
Actively control weeds	-.1968 N=63	-.0444 N=64	-.0632 N=66	-.1557 N=61	.0598 N=66	-.0059 N=67	-.0887 N=67	**.2550** N=67**
In-stream monitoring	.0943 N=46	.0961 N=46	**.3306** N=47**	.2669* N=45	**.3833*** N=47**	.1510 N=47	-.1806 N=47	.1012 N=47
Target Ground/grass cover %	-.0622 N=68	.0915 N=69	.0705 N=72	**-.2766** N=67**	-.0798 N=71	-.0566 N=72	-.0361 N=72	.0421 N=72

*** marked correlations are highly significant at $p < 0.01$

** marked correlations are significant at $p < 0.05$

* marked correlations are significant at $p < 0.10$

Pair wise deletion of data was used to maximise sample size.

Generally, those respondents who rated BMPs as an important risk management strategy had implemented them to a significantly larger extent than those who did not. The relationship was highly significant for de-stocking in preparation for drought, rotational grazing, fencing of highly erosive areas and temporary exclusion of cattle from riparian zones. There were exceptions, also, namely in relation to weed management, adjustment of stock numbers, use of fire and in-stream water monitoring. Rotational grazing was highly significantly correlated to the risk management strategy 'human capacity & knowledge', indicating the level of knowledge and skills perceived to be required to implement this grazing regime. A notable negative correlation existed between the target grass/ground cover that graziers had and the RMS 'expansion & diversification'. Respondents who rated price risk management as important tended to demonstrate more extensive implementation of pasture spelling during the wet season, rotational grazing , permanent exclusion of cattle from riparian zones and in-stream water monitoring.

5. Discussion

For this study we mined data from a previous survey of landholders in the Burdekin River catchment. Among the agricultural industries, only graziers provided sufficient responses to attempt an analysis of their implementation of grazing BMPs with respect to their goals and risk attitudes, both of which have been found to be important factors in adoption decisions. The sample size of n=94 was below the recommended minimum sample size for factor analysis but sufficient to justify an exploratory investigation. The issue of sample size was exacerbated for variables that had multiple non-responses. Low N might have caused some spurious results and we therefore reported N on a case-by-case basis and interpreted results with the necessary caution.

This study provides further empirical evidence of the diversity of goals and aspirations which motivate farmers, in this case cattle graziers. We were able to reduce this diversity to three motivation factors: economic/financial, social, and conservation & lifestyle, with respondents pursuing a combination of each of those to varying extents. Conservation & lifestyle goals were found to be the prime motivations among graziers in the Burdekin River catchment, confirming the great importance that farmers attach to lifestyle aspects of farming (Austin *et al.*, 1998)

This corresponds well with a study by Chouniard *et al.* (2006) into the motivations of farmers with respect to implementing conservation programs proposed farmers. They delineated three types of farmer and suggested that all farmers lied somewhere on a continuum between these types. The three types they suggested were: (i) pure profit-maximising (ii) ego-utility, i.e. values environment only to the extent that it provides direct personal benefits (iii) sense of obligation to others e.g. future generations. Maybery *et al.* (2005) identified three sets of values: economic, conservation and lifestyle as motivations for landholders in the NSW Murray region. They noted however that there was 'conceptual overlap' of lifestyle and conservation values. Their survey did not contain questions relating to social motivations, which may explain why this factor was not apparent. In our study, lifestyle and conservation motivations could not be separated through factor analysis. This would indicate that conservation goals tend to be intrinsically anthropocentric and intertwined with the core ethics and lifestyle of the operator, in the sense of ego-utility (Chouinard *et al*., 2006). In contrast, financial/economic and social goals would appear to be fitted to more external (e.g. satisfying the bank, comparison with other operators) or indirect (e.g. farming as a means to an end) goals.

Personal goals provide the principal driver for land management decisions (Pannell *et al.*, 2006) and understanding the sources of motivation is important in attempting to explain adoption of environmental practices (Toma & Mathijs, 2007). We could demonstrate that graziers with a high level of conservation & lifestyle motivation showed a significantly larger extent of implementation of a suite of grazing BMPs. No such highly significant relationships with implementation of grazing BMPs were demonstrated with regards to other motivation factors. This would support the conclusion that landholders with strong pursuit of lifestyle and conservation goals are more likely to adopt recommended conservation practices because the rationale for doing so aligns with their values and attitudes, their motivation for implementation of conservation practices is thus intrinsic. Landholders who are predominantly motivated by social and economic/financial goals might be looking for external motivators such as "incentives" to implement conservation practices.

A majority of grazier respondents in this study regarded themselves as risk takers with regard to the 'introduction of new practices'. Indeed, the 'implementation of BMPs' was identified by this study as a risk management strategy in its own right. No other similar study had separated this innovation out from productivity improvement as a risk management strategy. The strong correlations between perceived risk taking (with respect to introduction of new practices) and 'rotational grazing', 'early de-stocking in preparation for drought' and 'adjustment of stock numbers to pasture condition' suggest a widely held perception that these practices may not as yet be mainstream or widely accepted. This may also point to a possible bias in the sample to the effect that survey respondents may be more likely motivated by conservation and lifestyle goals and implementers of grazing BMPs than the general population of graziers in the Burdekin River catchment.

Graziers in the Burdekin Dry Tropics see themselves as susceptible to a variety of sources of risk, most notably drought, prices in input and commodity markets, government regulation, family health and environmental factors such as vegetation change, weed infestation and cattle disease. Through factor analysis, the list of 35 sources of risk was reduced to five factors: (i) family health, (ii) markets/prices, (iii) institutional risk, (iv) production risk and (v) severe drought. These factors relate well to the sources identified in other empirical studies (Topp & Shafron, 2006). The list of risk factors typically includes market and price risk, institutional risk (relating to legislation and the political situation), personal risk (relating to human risk and family health) and production risk. Production risk encompasses all risks which may affect the yield of the farming operation. The elements of production risk differ between crops and regions.

We further condensed 31 risk management activities into eight risk management strategies using factor analysis. The strategies included (i) productivity maximisation, (ii) human capacity & knowledge, (iii) price risk management, (iv) expansion & diversification, (v) family income diversification & (personal) insurance, (vi) expert advice, (vii) government assistance, and (viii) best management practice.

Various empirical studies vary in the level of aggregation of risk management strategies and the focus of strategies. Stordal *et al.* (2007) differentiated between (i) harvesting strategies, (ii) outside assistance, (iii) insurance and (iv) off-property activities. Flaten *et al.* (2005) identified seven risk management strategies of Norwegian dairy farmers, including (i) consultancy, (ii) disease prevention, (iii) flexibility, (iv) insurance, (v) diversification, (vi) financial and (vii) fixed cost sharing. Ortmann *et al.* (1995), in a South African study focused on six financial and production strategies, while Harwood *et al.* (1999) identified eleven business and financial risk management strategies. They also found that larger farms were more likely to apply a range of risk management strategies compared to small family operations.

We found few correlations between how graziers assessed risk based on the source-of-risk factors and the extent to which they had implemented grazing BMPs. Interestingly, 'severe drought' was negatively correlated to the BMP 'permanent exclusion of cattle from riparian zones', which may suggest that graziers who are particularly worried about drought reject the idea of not grazing riparian zones at all. On the other hand, there was a positive correlation between the source of risk 'markets/prices' and the best management practice 'temporary exclusion'. Four of the top ten source-of-risk items were within the 'markets/prices' factor, thus a large proportion of graziers might be likely to temporarily exclude cattle form riparian zones to help manage market risks. The positive correlation between 'institutional' sources of risk and the best management practice 'fence off highly erosive areas' could indicate that perceived threats of environmental regulation lead graziers to take preventative action, e.g. through fencing for soil conservation.

Our study found no correlations between the relative risk assessment of graziers and their assessment of source of risk (on a factor basis). This supports the notion that "farmers' perceptions of themselves are not highly consistent with their responses about risk management tools or scientifically based risk attitudes" (Bard & Barry, 2000).

The strong positive correlation between the 'conservation and lifestyle' goal and the risk management strategy 'best management practices' further affirms the connection between conservation and lifestyle motivations, the existing level of implementation of conservation practices, and the view that conservation practices assist in managing the risk encountered by grazing operations. While a positive correlation also exists for socially motivated graziers, this does not translate into higher adoption levels. Economically motivated graziers specifically do not regard BMPs as a risk management strategy and may attribute a higher option value to delayed adoption (Marra *et al.,* 2003).

The higher graziers assessed any or all risk factors, the more they embraced productivity maximisation as a risk management strategy. The more concerned graziers are about the risk of 'severe drought' the more they implemented a whole suite of risk management strategies. Respondents who rated institutional risk as high specifically embraced 'expansion and diversification' and price risk management, but showed no interest in pursuing government assistance. They might consequently be the most difficult to engage in programs to foster adoption of BMPs. Notably, BMPs as a risk management strategy were specifically embraced, along with price risk management, by respondents who gave market/price risks a high rating. This would suggest that these graziers see how they can use BMPs, specifically those associated with fencing and spelling, to support market management strategies as well as productivity goals.

6. Conclusions

This paper reports on an exploratory investigation where we have mined data from a previous survey of landholders in the Burdekin River catchment. Among the industries, only graziers provided sufficient responses to attempt an analysis of their implementation of grazing best management practices with respect to their goals and risk attitudes.

We have demonstrated that motivations for farming/grazing and risk attitudes significantly relate to the extent to which graziers in the Burdekin Dry Tropics adopt conservation practices targeted at water quality improvements and the types of conservation practices they choose to adopt. The research thus provides further support for the long-held and often stated view that adoption processes are strongly affected by risk-related issues (Marra *et al.*, 2003).

Graziers with a high level of conservation & lifestyle motivation showed a significantly larger extent of implementation of a suite of grazing BMPs. Preferred BMPs included maintenance of grass cover (supported by pasture monitoring), fencing to land type, spelling of pastures and riparian zones, early destocking in preparation for drought, and rotational grazing. We found a certain level of specificity of preferred BMPs, depending on motivation and risk assessment factors, which supports the view that "people who adopt one innovation early are not necessarily early adopters of all innovations" (Pannell *et al*., 2006).

The implementation of BMPs is a risk management strategy most readily embraced by graziers with high conservation & lifestyle motivation, but some BMPs are also valued for their support of price and market risk management. It would appear from this research that the concept of conservation practices, or more specifically BMPs, is most readily embraced by those graziers (landholders) who see their use fitting neatly within their conservation and lifestyle driven decision making framework. It would appear that additional incentives are required to entice economically and socially motivated graziers (landholders) to adopt BMPs.

This research suggests that the design of NRM policies and programs at the regional level ought to be guided by a better understanding of the goals and risk attitudes of landholders so as to be able to tailor incentives and maximise their effectiveness and efficiency. Clearly, in the context of the CCI developing and promoting BMPs, the current strategy appeals predominantly to conservation and lifestyle motivated landholders.

The results of this research suggest that landholders with strong pursuit of lifestyle and conservation goals are more likely to adopt recommended conservation practices because the rationale for doing so aligns with their values and attitudes, their motivation for implementation of conservation practices is thus intrinsic. Landholders who are predominantly motivated by social and economic/financial goals might be looking for external motivators as "incentives" to implement conservation practices. Further analysis of the data is required to (i) test whether it yields empirical evidence to support this suggestion and (ii) investigate a possible link between the appeal of different policies and programs to landholders and their risk attitudes and risk management strategies, as suggested by Maybery *et al.* (2005).

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9. Abbreviations

BMPs	Best management practices
CCI	Coastal Catchment Initiative
GBR	Great Barrier Reef
NRM	Natural resource management
PCA	Principal Component Analysis