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Implementation costs of Agricultural Management Practices for Water Quality Improvement in the Great Barrier Reef Catchments

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EXECUTIVE SUMMARY

In this report we analyse implementation costs and benefits for agricultural management practices, grouped into farming systems. In order to do so, we compare plot scale gross margins for the dominant agricultural production systems (sugarcane, grazing and banana cultivation) in the NRM regions Wet Tropics, Burdekin Dry Tropics and Mackay Whitsundays. Furthermore, where available, we present investment requirements for changing to improved farming systems. It must be noted that transaction costs are not captured within this project.

For sugarcane, this economic analysis shows that there are expected benefits to sugarcane growers in the different regions through transitions to C and B class farming systems. Further transition to A-class farming systems can come at a cost, depending on the capital investment required and the length of the investment period. Obviously, the costs and benefits will vary for each individual grower and will depend on their starting point and individual property scenario therefore each circumstance needs to be carefully considered before making a change in management practice.

In grazing, overall, reducing stocking rates comes at a cost (reduced benefits). However, when operating at low utilisation rates in wetter country, lowering stocking rates can potentially come at a benefit. With win-win potential, extension is preferred to assist farmer in changing management practices to improve their land condition. When reducing stocking rates comes at a cost, incentives may be applicable to support change among farmers.

For banana cultivation, the results indicate that the transition to C and B class management practices is a worthwhile proposition from an economic perspective. For a change from B to A class farming systems however, it is not worthwhile from a financial perspective. This is largely due to the large capital investment associated with the change in irrigation system and negative impact in whole of farm gross margin. Overall, benefits will vary for each individual grower depending on their starting point and their individual property scenario.

The results presented in this report are one possible set of figures to show the changes in profitability of a grower operating in different management classes. The results in this report are not prescriptive of every landholder. Landholders will have different costs and benefits from transitioning to improved practices, even if similar operations are practiced, hence it is recommended that landholders that are willing to change management undertake their own research and analysis into the expected costs and benefits for their own soil types and property circumstances.

1. INTRODUCTION

This report provides an analysis of the implementation costs and benefits of agricultural management practice(s) change for water quality improvement in the Great Barrier Reef (GBR) catchments, to be more specific, the Natural Resource Management (NRM) regions of the Wet Tropics (WT), Burdekin Dry Tropics (BDT) and Mackay Whitsundays (MWS) (see Table 1). We define implementation costs and benefits as composing of 1) long term productivity changes due to changed management (presented as farm gross margins[1]) and 2) capital investments required to change management. From Van Grieken et al. (2010a) we will identify the management actions for each identified production system.

The industries shown in Table 1 are the key industries in the GBR region from 1) an economic point of view, 2) agricultural area in the catchment as well as 3) their current contribution to water pollution, as identified in Van Grieken et al. (2010a).

Table 1: Key production systems per region

Production system	*Dominant region*
Sugarcane	Wet Tropics, Burdekin Dry Tropics, Mackay Whitsundays
Grazing	Rangelands (BDT), wet coastal grazing (WT)
Horticulture	Wet Tropics (bananas)

Table 2 describes the priority management actions for each identified industry to address the issue of water pollution by nutrients, pesticides and sedimentation (Van Grieken et al., 2010a).

Table 2: Priority management actions per production system

Production system	*Priority actions*
Sugarcane	Nutrient, Pesticide and Soil management
Grazing	Pasture (reduced stocking rates), Riparian (river frontage) and Gully management
Horticulture	Nutrient, soil management, insect/disease and irrigation management

Prioritisation of management practices is adopted from Van Grieken et al. (2010a) and summarised in Table 3. In this report the grouping of management practices is referred to as management or practice classes or farming systems and will be used interchangeable throughout the report.

[1] Gross margin is the difference between the sales revenue and the production costs excluding overhead, taxation and interest payments.

Table 3: Management practice classification

Practice class / farming system	*Description*
A: Aspirational	Proof of concept, practice/farming system under research/scientifically sound but commercial viability not yet proven
B: Best	Best practice / farming system currently available
C:Common	Currently code of practice level of farming system
D: Dated	Dated and likely degrading practice / farming system

For sugarcane in the WT, BDT and MWS we provide information on environmental benefits (nutrient reductions) from transition and we furthermore synthesise work that has been undertaken under Reef Rescue Monitoring and Evaluation Paddock to Reef Program Sugarcane Economics (Van Grieken et al., 2010b) to identify steady state farm gross margins, investment costs required to make the transition between farming systems and a net present value (NPV) analysis to determine the viability of the transition. For grazing in the BDT (rangeland) we analyse long term productivity costs and or benefits and quantify indicators for pollutant reductions. For banana cultivation we determine steady state gross margins, capital requirements and a NPV analysis for transition. Furthermore we perform a future cash flow risk analysis for variations in the market price of bananas as well as variations in expected yields.

1.1. Methodology

As mentioned, the analysis undertaken in this project determines implantation costs and benefits of changing management for water quality improvement as. This analysis involves a few steps:

1. **Environmental indicators - Steady state[2] -** Determine paddock scale pollutant loads (or indicators)
2. **Farm gross margins – Steady state -** Determine farm productivity (yield, prices) and financial (costs) and indicators for operating in a specific (steady state) farming system
3. **Investment costs – Transition state[3] -** Determine capital costs (investments) required to change to an ‘improved’ farming system

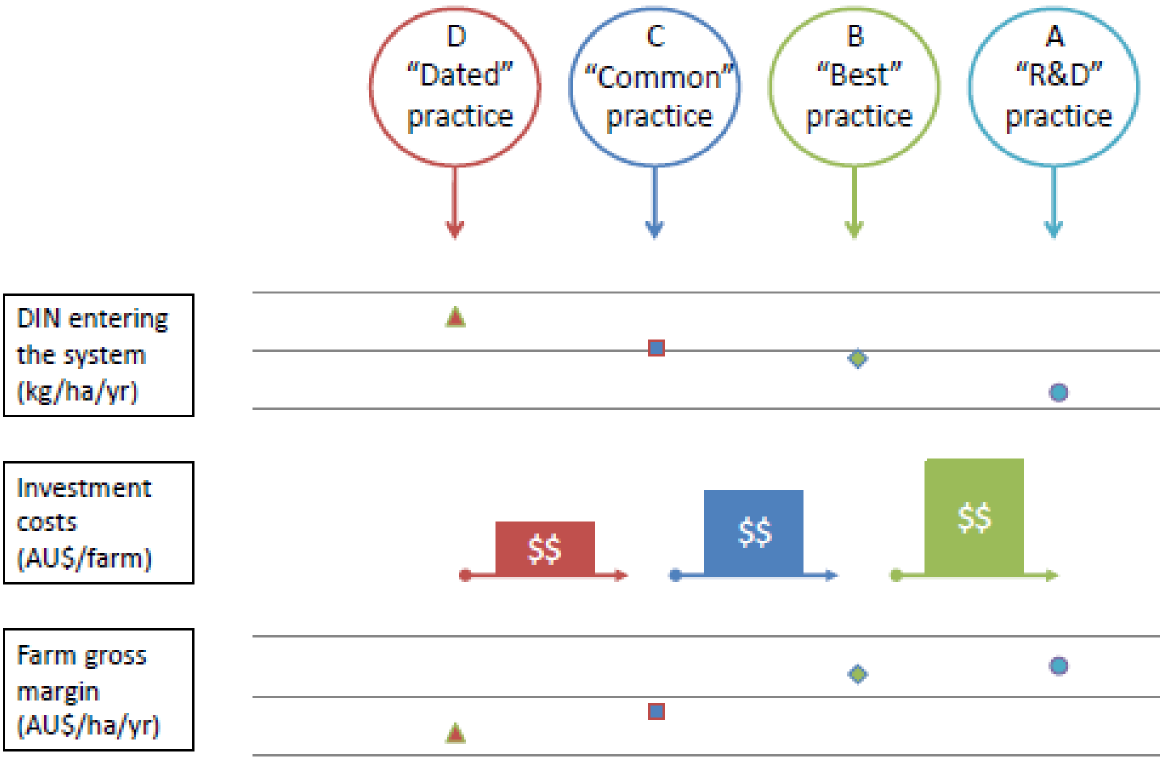
This report is structured such that it will describe these steps is detail for each of the identified industries. In short, to determine farm gross margins as well as capital costs associated with investments for change, representative (regional average) enterprises are constructed (based on expert opinion). This approach allows us to value not only the cash flow and other financial indicators for the farm in steady state, but also the changes in farm operations, inputs and labour associated with management change on the farm. To predict both changes in productivity (yields) and environmental benefits, production system simulation, where available, is utilised. More specifically, for sugarcane, APSIM (Keating et al., 2003) is used to predict long term productivity (cane yield) indicators of changes to management, where FEAT (Cameron, 2005) is used to document financial variables. For grazing GRASP (Littleboy & McKeoon 1997, Rickert et al. 2000) is used to predict changes in grass basal area as the indicator for potential sediment loss reduction, in combination with ENTERPRISE to determine the gross margin and enterprise profitability. For banana cultivation, a custom made spreadsheet was used for the financial cost analysis (developed

[2] With steady state we refer to the farm operating (long term) in a specific farming system.
[3] With transition state we refer to the farm changing management from one farming system to the next.

by Jim Page, DEEDI) of steady state gross margins and the cost of change. We do not provide an indicator for environmental improvement nor changes in yields (for gross margin calculations) since currently there is no accurate production simulation model available for banana growing.

Systematically, results from step 1 to 3 are presented in Figure 1. In this way we present the effectiveness to improve water quality for a specified farming system while identifying changes in long term profitability and short term investment costs to facilitate the required change.

Figure 1: Implementation costs and benefits for farming system transition



It is recognised that in many cases the grouping of practices into farming systems may not be entirely realistic. Farmers will tend to select the mix of practices which best suits their circumstances. Furthermore, each farming business is unique in its circumstances and therefore the parameters and assumptions used in this analysis do not per definition reflect individual situations farmers face. Nevertheless, these groupings do provide a useful structure in which to analyse the key changes to water quality and the financial impacts of management change.

In the reminder of this report each industry analysis is presented for sugar, grazing and banana cultivation in turn. A brief discussion of the results completes this report.

2. SUGARCANE

As fertiliser is the dominant source of dissolved inorganic nitrogen (DIN) water pollution (Armour et al. 2009), effective management strategies for sugarcane growing have been developed and are being developed to address this issue. Therefore, for sugarcane, in this report we will focus on the reduction of DIN entering the waterways.

For each farming system we identify and estimate environmental indicators, long term productivity costs and benefits (gross margins) and the investment costs to facilitate change to improved farming systems. In order to determine these numbers, MTSRF project 3.7.5 has collaborated with Reef Rescue M&E Paddock to Reef project Cane Economics (P2R CE; Van Grieken et al., 2010b). MTSRF project 3.7.5 has provided a detailed overview of farming system operations, including detailed description of management actions for water quality improvement (Van Grieken et al., 2010a), as well as productivity (yield) indicators, to form the basis for economic analyses in the WT region, BDT River Irrigation Area (BRIA) region, BDT Delta region and MWS region.

Within the P2R CE project (Van Grieken et al. 2010b), for each individual region, dominant soil type and representative farm size has been determined via expert consultation and used to construct representative farms using the Farm Economic Analysis Tool (FEAT; Cameron, 2005). FEAT for sugarcane has been developed by the Department of Primary Industries and Fisheries (DPI&F, now DEEDI) and is used to estimate financial indicators of a farm operating in a specified farming system. It provides the gross margin for plant cane and each cane ratoon, as well as for fallow crops (e.g. soy bean). For a more detailed description of the FEAT tool, the assumptions made to perform the analysis, gross margin calculations and direct cost of change (capital investments) refer to Van Grieken et al. (2010b). The P2R CE report describes in detail the methodology for capturing financial economic data in the WT, BDT and MWS sugarcane farming systems, as well as the assumptions that were made. A few examples of the representative farm parameters and the market are presented in Table 4.

Table 4: Representative farm parameter settings

NRM region	*WT*	*BDT BRIA*	*BDT Delta*	*MWS*
Soil type	Sandy loam	Cracking clay	Medium clay	Silty clay with light clay subsoil
Farm size	120ha	240ha	120ha	150ha
Sugar price[4]	$349.30	$349.30	$349.30	$349.30
Commercial Cane Sugar (CCS)[5]	12.86	14.94	14.94	13.71

2.1. Environmental indicators

In Table 5 we present total averaged fertiliser use (over the crop cycle) and DIN available for runoff and deep drainage leaching per hectare per year for each region, each farming system (A, B, C and D) and each of the dominant soil types in the corresponding regions, based on APSIM simulations.

[4] The sugar price is the 5 year average between 2005 and 2009.
[5] The CCS is based on the 5 year average CCS for the region specific sugar mill.

Table 5: Wet Tropics paddock scale environmental indicators

*Soil type**	*Farming system*	*N Fertiliser use (kg/ha/yr)*	*N Runoff (kg/ha/yr)*	*N Leached (kg/ha/yr)*	*N Total (kg/ha/yr)*
S1	A: Aspirational	65.0	0.1	22.3	22.3
S1	B: Best	100.0	0.5	37.6	38.2
S1	C: Common	118.9	4.1	37.7	41.9
S1	D: Dated	142.5	4.9	52.5	57.5
S2	A: Aspirational	56.4	0.1	9.2	9.3
S2	B: Best	100.0	0.9	22.0	22.9
S2	C: Common	118.9	4.2	21.5	25.6
S2	D: Dated	142.5	4.5	34.9	39.4
S3	A: Aspirational	55.1	0.2	8.2	8.4
S3	B: Best	83.3	1.4	13.1	14.4
S3	C: Common	118.9	7.5	14.3	21.8
S3	D: Dated	142.5	8.2	22.9	31.1
S4	A: Aspirational	47.5	0.1	5.3	5.5
S4	B: Best	100.0	1.3	16.3	17.6
S4	C: Common	118.9	6.8	14.4	21.3
S4	D: Dated	142.5	7.7	25.0	32.7

** Soil type descriptions:*
S1: Well drained sandy loam soil of granitic origin
S2: Loam soil poorly drained formed on alluvium
S3: Red clay loam soil slowly drained formed on basaltic rock origin
S4: Medium to heavy clay soil generally well drained formed on alluvium

Table 6: Burdekin Dry Tropics paddock scale environmental indicators

Soil type	*Farming system*	*N Fertiliser use (kg/ha/yr)*	*N Runoff (kg/ha/yr)*	*N Leached (kg/ha/yr)*	*N Total (kg/ha/yr)*
BRIA	A: Aspirational	65.4	4.6	1.5	6.2
BRIA	B: Best	101.6	8.9	2.6	11.5
BRIA	C: Common	174.0	8.8	27.0	35.8
BRIA	D: Dated	305.4	31.3	49.9	81.2
Delta	A: Aspirational	89.9	24.3	0.3	24.6
Delta	B: Best	113.6	37.0	0.3	37.4
Delta	C: Common	174.0	41.0	3.2	44.2
Delta	D: Dated	305.4	126.6	8.5	135.1

Table 7: Mackay Whitsundays paddock scale environmental indicators

Soil type	Farming system	N Fertiliser use (kg/ha/yr)	N Runoff (kg/ha/yr)	N Leached (kg/ha/yr)	N Total (kg/ha/yr)
Eton	A: Aspirational	60.1	1.4	8.3	9.7
Eton	B: Best	86.7	2.5	16.3	18.8
Eton	C: Common	144.0	9.3	14.3	23.7
Eton	D: Dated	192.0	10.5	31.0	41.5
Marian	A: Aspirational	56.1	0.7	17.1	17.8
Marian	B: Best	93.3	2.0	33.2	35.2
Marian	C: Common	144.0	7.2	27.5	34.7
Marian	D: Dated	192.0	7.8	52.4	60.2
Tekowai	A: Aspirational	53.1	0.6	15.3	15.8
Tekowai	B: Best	93.3	1.1	33.6	34.8
Tekowai	C: Common	144.0	3.1	37.6	40.7
Tekowai	D: Dated	192.0	3.3	65.6	69.0

In general, improved practices show significant reductions in DIN available for runoff and deep drainage leaching.

2.2. Farm gross margins

Below we present estimates of total cane harvested in tonnes per hectare per year for each region, each farming system and each of the dominant soil types in the corresponding regions, based on APSIM simulations. The soil types refer to either the area (BDT BRIA and Delta) or the geographical approximation (MWS) of the calibration site. For the WT, S1 refers to a well-drained sandy loam soil of granitic origin; S2 to a loam soil, poorly drained formed on alluvium; S3 to a red clay loam soil, slowly drained formed on basaltic rock origin; and S4 to a medium to heavy clay soil, generally well drained formed on alluvium.

Table 8: Wet Tropics farming system yields

Soil type	S1 soil	S2 soil	S3 soil	S4 soil
Farming system	Yield (t/ha/yr)	Yield (t/ha/yr)	Yield (t/ha/yr)	Yield (t/ha/yr)
A: Aspirational	83	72	70	61
B: Best	84	74	72	64
C: Common	81	71	70	61
D: Dated	81	71	70	61

Table 9: Mackay Whitsundays farming system yields

Soil type	Eton soil	Marian soil	Tekowai soil
Farming system	Yield (t/ha/yr)	Yield (t/ha/yr)	Yield (t/ha/yr)
A: Aspirational	73	69	65
B: Best	74	70	66
C: Common	73	69	66
D: Dated	73	70	66

Table 10: Burdekin Dry Tropics farming system yields

Soil type	*BRIA soil*	*Delta soil*
Farming system	*Yield (t/ha/yr)*	*Yield (t/ha/yr)*
A: Aspirational	93	125
B: Best	96	131
C: Common	90	123
D: Dated	90	123

In all but one case, moving from D and C to B farming systems may lead to increased yields. Moving to A farming systems lowers the yields slightly; however the decreased benefits may be offset against decreased inputs and or labour requirements for these farming systems.

Table 11 presents the gross margins for the various farming systems in the various NRM regions. For more detail on the assumption and parameters used, as well as detailed descriptions of various financial indicators refer to Van grieken et al., 2010b.

Table 11: Farm gross margins per region

NRM region *Farming system*	*WT*	*BDT Delta*	*BDT BRIA*	*MWS*
A: Aspirational	$1,124	$3,025	$1,539	$847
B: Best	$1,096	$2,959	$1,439	$713
C: Common	$943	$2,525	$1,231	$655
D: Dated	$856	$2,197	$875	$498

As we stated before, moving from D and C to B and A farming systems may lead to productivity benefits due to increased yields, decreased inputs and reductions in operational labour time.

2.3. Investment costs

For a detailed description of all the actions required to make the changes between the various farming systems per region refer to Van grieken et al. (2010b). Table 12 showes the estimated aggregate investment costs required for changing to another farming system. Examples of investments for the transition from C class to B class are the purchase and or modifications to tool splitter fertiliser boxes, sprayers, bed formers, harvesters and tractors. Moving from class B to class A requires e.g. the purchase of a GPS on the farm tractor, a shielded sprayer and a trash splitter.

Table 12: Investment costs per region

Investment costs ($) *Farming system change*	*WT (Tully)*	*BDT Delta*	*BDT BRIA*	*MWS*
B to A	$88,000	$83,000	$86,000	$49,000
C to B	$59,000	$69,000	$74,000	$50,000
D to C	-	-	$35,000	$10,000

The increased farm gross margin from changing to 'improved' farming systems is in some cases offset by the investment costs that farmers have to incur. In other words, the number of years before the farmer actually enjoys the benefits of his investment differs, depending on the amount of the investment and the discount rate used to discount the future cash flows (by increased benefits). A net present value (NPV) analysis for the ABCD farming systems per region is synthesised from Van Grieken et al. (2010b) and presented in Table 13 (5 years) and Table 14 (10 years). A real discount rate of 7% (adjusted for inflation rate) has been used to convert the future cash flows of the cane growing business to their present values (value in today’s dollar terms).

Table 13: Net present value analysis 5 years

Region ($) *Farming system change*	*WT (Tully)*	*BDT Delta*	*BDT BRIA*	*MWS*
B to A	-$74,426	-$50,424	$12,970	$28,204
C to B	$16,621	$144,502	$130,851	-$12,300
D to C	$42,627	$161,185	$332,345	$86,548

Table 14: Net present value analysis 10 years

Region ($) *Farming system change*	*WT (Tully)*	*BDT Delta*	*BDT BRIA*	*MWS*
B to A	-$64,748	-$27,197	$83,535	$83,387
C to B	$70,538	$296,727	$279,846	$19,788
D to C	$73,020	$276,107	$594,256	$155,386

Furthermore, transaction costs (or 'hidden' costs change) e.g. the time spent purchasing new equipment and learning about improved practices and equipment can potentially be a barrier for change. These potential costs however, have not been included in this analysis.

3. GRAZING

In North Queensland's rangeland grazing lands, one of the most important management influences on the amounts of sediments entering waterways is pasture management and maintaining a good ground cover of perennial tussock grasses. Where pasture cover is reduced through poor grazing management, the soil is exposed more strongly to the effects of erosive tropical and subtropical rainfall. The accompanying loss of soil is not only an issue for sediment loads and their impacts downstream, but can also permanently reduce the productive capacity of pastures (creating a vicious cycle where stocking rates need to be further reduced if continued overgrazing and pasture deterioration is to be avoided). One of the primary management influences to reduce sediment flows off grazing lands is therefore improved pasture/grazing management to maintain and enhance the protective cover of perennial grasses. This includes practices such as setting stocking rates that are safely matched to the productive capacity of the land, wet season spelling to assist recovery of degraded pastures, and strategies for dealing with climate variability such as conservative stocking rates or adjusting stocking rates based on seasonal forecasts. (Soils are particularly susceptible to erosion when good rains return after droughts if grazing management has not maintained protective ground cover during the drought). In this study, we therefore used grass basal area (BA) as the indicator of management performance for limiting sediment yields. For management classes we used changes in stocking rate as a generic proxy variable to represent a range of grazing management practices that could improve pasture condition. The management classes, starting conditions of the land and the specific management actions are presented in
Table 15.

Table 15: Management practice and land condition classification Rangelands

Management class	*Land starting condition (cover)*	*Management action*
A: Aspirational	-	Reduced stocking rate (47%)
B: Best	Good	Reduced stocking rate (23%)
C:Common	Medium	Maintain stocking rate (0%)
D: Dated	Poor	-

For each class we identify and estimate environmental indicators and long term productivity costs and benefits (gross margins) of improved farming systems. To facilitate this, a representative farm size has been determined via expert consultation. GRASP (Littleboy & McKeoon 1997, Rickert et al. 2000) is used to predict changes in grass basal area as the indicator for potential sediment loss reduction, in combination with ENTERPRISE to determine the gross margin and enterprise profitability.

The rangelands area of the Burdekin Dry Tropics was divided into three zones of approximately equal area based on average annual rainfall (Figure 2).

Figure 2: Burdekin rainfall zones

The GRASP and Enterprise models were parameterised for these three zones using parameter sets from a recent previous study in this region (Ash et al., 2002). The key sets of parameters governing the behaviour of the grass production model were: 1) available nitrogen; 2) soil moisture storage characteristics; and 3) grass growth characteristics. Daily weather data was obtained for the three weather stations in region that most closely represented the average rainfall for each of our three specified rainfall zones: Charters Towers (660 mm), Bulliwallah (590 mm) and Jericho (520 mm). Although Jericho is just outside the Burdekin catchment, it was the nearest station that could be found with approximately 520mm average, and had 100 years of data.

The parameter of both models, GRASP and ENTERPRISE, are presented in Table 16.

Table 16: Representative farm parameter settings for GRASP and ENTERPRISE

Parameter	***Initial setting***	***Comment***
GRASP		
Soil layers	4	Level 4 for trees only
Maximum water content	268mm	L1-18, L2-120, L3-130, L4-100
Minimum water content	143mm	L1- 8, L2 – 65, L3-70
Potential annual live weight gain (LWG)	130kg	At a low stocking rate
Pasture yield at 50% cover	1500kg/ha	
Slope of land	2%	
Pasture basal area	3%	
Tree basal area	4%	
Pasture condition	90%	Proportion of perennial species
Maximum N uptake	15 kg/ha	
ENTERPRISE		
Property size	28000ha	90% usable for grazing
Dry Cow culling rate	20%	
Weaner heifer retention rate	20%	
Weaner steer retention rate	90%	
Weaning weight	170kg	
Target selling weight	575kg	Or sold at 4 years
Selling prices – export bullocks	1.85	$/kg live weight
- light steers	1.75	
- heifers	1.65	
- cull cows	1.45	
Sales commission	5%	
Transport costs	$1.30/kl	Deemed 250kl, 20-25 animals/load
Supplement -1	$600/t	80% molasses, 20% urea
Supplement -2	$1050/t	87% molasses, 3% urea, 10% cottonseed meal
Sundry costs	$6.40/head	Mustering, yard fees, slaughter levy, …

3.1. Environmental indicators

In each rainfall zone, we evaluated how land starting in poor, medium and good condition would respond to improvements in grazing management. At the start of each model run, GRASP was run for the most recent 30 years of weather data (1979-2008) using high (30%), medium (20-25%) and low (15%) utilization rates to achieve the three different starting levels for land conditions. The utilization rate is the percentage of grass produced in a year that consumed by livestock. Stocking rates were adjusted in GRASP until these target utilization levels (and associated land conditions were achieved).

Following the start-up 30-year period to establish differences in initial land condition, the model was run for a further 100 years (using weather data for 1909-2008) to simulate the effects of three alternative management scenarios. The management scenarios were represented by adjustments to the utilization rates:

1) Maintain the initial utilization rate used in the start-up 30 years;
2) Reduce stocking rate by 23% (which represented the proportional change in stocking rate required to move from high (30%) to moderate utilization (20-25%) as determined in setting the starting land condition); and
3) Reduce stocking rate by 47% (which represented the proportional change in stocking rate required to move from high utilization to low utilization).

For each climate zone there were a total of nine simulations: three different initial levels of land condition each tested for three management scenarios. Table 17 to 19 present the results for grass basal area for each of the land conditions for each of the rainfall areas.

Table 17: Grass basal area - B land condition: 15% utilisation

Grass basal area *Farming system*	*B land – 660mm*	*B land – 590mm*	*B land – 520mm*
B: Maintain stocking rate	3.562	2.793	1.824
B^+: Reduced stocking rate (23%)	3.590	2.840	1.852
A: Reduced stocking rate (47%)	3.631	2.882	1.874

Table 18: Grass basal area - C land condition: 22.5% utilisation

Grass basal area *Farming system*	*C land – 660mm*	*C land – 590mm*	*C land – 520mm*
B: Maintain stocking rate	3.449	2.649	1.755
B^+: Reduced stocking rate (23%)	3.525	2.740	1.804
A: Reduced stocking rate (47%)	3.585	2.835	1.845

Table 19: Grass basal area - D land condition: 30% utilisation

Grass basal area *Farming system*	*D land – 660mm*	*D land – 590mm*	*D land – 520mm*
B: Maintain stocking rate	3.343	2.526	1.654
B^+: Reduced stocking rate (23%)	3.445	2.662	1.741
A: Reduced stocking rate (47%)	3.547	2.799	1.804

3.2. Farm gross margins

The stocking rate and animal live weight gain data output from the GRASP analyses was loaded into the ENTERPRISE model to determine the gross margin and enterprise profitability of the 9 variations for each climate zone. Supplements were fed when predicted annual live weight gain (LWG) was less than 50kg/head (supplement 1) or less than 0kg/head (supplement 2). Calving rates and mortality were based on cow condition (annual LWG), with a maximum calving rate of 90%. Mortality rates were approximately 3% and 2% for breeders and dry animals under good conditions, increasing to 9 and 5% respectively when annual live weight gain decreased to 50kg. All animals were supplied with P supplement during the wet season.

Table 20 to 22 present the results from the modelling exercise for the three rainfall areas. For each starting condition it shows the gross margins and grass basal area for current and reduced stocking rates (23% and 47%).

Table 20: Farm gross margins - B land condition: 15% utilisation

Farm gross margin ($/ha/yr) *Farming system*	*B land – 660mm*	*B land – 590mm*	*B land – 520mm*
B: Maintain stocking rate	$16.27	$9.94	$3.08
B^+: Reduced stocking rate (23%)	$12.79	$8.36	$2.61
A: Reduced stocking rate (47%)	$9.01	$6.21	$1.87

Table 21: Farm gross margins - C land condition: 22.5% utilisation

Farm gross margin ($/ha/yr) *Farming system*	*C land – 660mm*	*C land – 590mm*	*C land – 520mm*
B: Maintain stocking rate	$22.92	$12.59	$3.97
B^+: Reduced stocking rate (23%)	$18.44	$11.04	$3.30
A: Reduced stocking rate (47%)	$13.22	$8.54	$2.74

Table 22: Farm gross margins - D land condition: 30% utilisation

Farm gross margin ($/ha/yr) *Farming system*	*D land – 660mm*	*D land – 590mm*	*D land – 520mm*
B: Maintain stocking rate	$27.19	$13.68	$4.14
B^+: Reduced stocking rate (23%)	$22.48	$12.29	$3.94
A: Reduced stocking rate (47%)	$16.43	$9.71	$3.22

Generally, reducing stocking rates come at a cost (reduced benefits). However, when operating at low utilisation rates (15%), in wetter country (660 mm), lowering stocking rates from 23% to 47% will come at a benefit. The same goes for medium utilisation rates (22.5%), dry country (520 mm). It must be noted that in the analysis presented, investment costs are not assessed.

4. BANANAS

The economic analysis is based on the baseline year 2008 because the farming systems identified for banana cultivation in Van Grieken et al. (2010a) are from this year. Therefore, some of the mechanical operations, chemical use and fertiliser use may not necessarily link up with current management practices. While the ABCD framework provides descriptions, level of planning and record keeping, and machinery for each management class, it does not go to the fine detail of specifying the exact number and type of machinery operations used by growers in each management class. This project utilised expert agronomist advice to outline the operations that could/would be practiced by growers in each class. Information was also sourced through previous work undertaken Wegscheidl and Page (2010) and Roebeling et al. (2007) in the North Queensland Banana industry. This preliminary economic analysis provides an insight into the possible capital costs and financial implications associated with a change in management practice. Further time and resources will be required to validate this data further and to investigate other possible scenarios for farmers. Limitations with some of the economic data collected are outlined in this report.

The initial representative farm parameter settings that were used for this analysis are presented in Table 23.

Table 23: Representative farm parameter settings

	Description
	60 hectare Banana farm: representing a typical farm size for the region. Banana price: $20/carton. *Crop production data based on information provided from DEEDI agronomists and is held constant across all management practices. Average production is assumed to be 2867 cartons per hectare. *Soil type: Alluvial Soil / Riverbank. *Nutrient management is based on the Banana ABCD management practice framework document. Crop cycle consists of fallow, plant and six ratoon crops. Each part of the crop cycle has an equal proportion of land area. *Canola fallow crop grown for green manure in fallow area in B and A class management. Contractors used for spraying insecticides and fungicides. Contract spraying cost: $30/ha. Fuel price without GST and after rebate: $0.75/L. Labour cost: $22/hour. Soil tests are $130 each and leaf test are $50 each. Bare fallow used in D and C class management. Lime is applied in the fallow area of B and A management classes. *Detailed machinery operations, fertiliser application rates and chemical application rates are contained in Van Grieken et al. (2010a). *Irrigation water applied changes with each of the management practices. The economic analysis is a steady state analysis for a representative property operating exclusively in each farming system. In reality, most farms would operate across a few farming systems, and there would varying periods of transition. This analysis assumes that the transition to a new farming system occurs in the first year. All chemical and fertiliser prices are based on April 2010 figures. Figures are exclusive of GST where applicable.

** Data needs to be further validated to ensure that the figures are realistic and accurate.*

4.1. Farm gross margins

Because of the complexity involved in the economic calculations, a custom made spreadsheet was used for the economic analysis. The spreadsheet was developed by Jim Page (DEEDI Economist). The marginal cash flow differences for each farming system were simulated over a 5-year and 10-year planning horizon to determine the Net Present Value of changing across different farming systems. PiRisk (DEEDI) was added to the Excel Workbook to conduct stochastic simulations to evaluate risk. The process of risk analysis allows us to test uncertain parameters in an economic analysis and determine the potential risk associated with a change in value. In this economic analysis, a risk analysis was completed for banana price, banana yield, and irrigation water use to determine its impact on net present value. Net present value is a profitability indicator and aids in making a decision as to whether a change in farming system is worthwhile from an economic perspective.

The main objective of this section is to identify the gross margins in a banana farming business. The economic analysis focuses on two types of fallow management, bare fallow and Canola fallow grown for green manure. It is assumed that no revenue is received from these green manure crops. It is assumed that a bare fallow is used in C and D farming systems. Labour has been treated as a variable cost ($22/hr) in the gross margin analysis to allow for a more accurate comparison between farming systems.

Table 24 shows a trend of increasing farm gross margin per hectare as farming systems change from D class through to B class. This trend is largely associated with savings in tillage, fertiliser, weed control and labour costs in the plant and ratoon cane crops. The gross margins for A and B class farming systems are very similar. Although a reduction in irrigation and fertiliser costs occurred in A class farming systems, the additional cost of composting and spreading green waste in the field offset these financial benefits. A Canola fallow crop is grown in A and B class farming systems, providing soil health benefits to the fallowing plant crop. The fallow gross margin is negative for A, B, C and D farming systems due no revenue generated from a Canola green manure crop. As anticipated, the gross margin for plant crops is lower than ratoon crops because of the higher input costs associated with plant crop operations (e.g. tillage and planting).

Table 24: Banana gross margins

Farming system	*Farm GM/ha*
Aspirational (A)	$10,635
Best (B)	$10,646
Common (C)	$8,078
Dated (D)	$4,993

4.2. Investment costs

Table 25 shows the potential practice changes that a grower may undertake in the transition from one farming system to another. The changes listed will vary slightly for every individual business depending on their soil type, scale, machinery, access to contractors, and desire to improve. Most of these potential changes are captured in the economic analysis; however some are excluded such as the cost of better record keeping and further training or education.

Table 25: Potential practice changes

Transition	*Description*
D class to C class	Avoid cultivation during high risk (heavy rainfall) periods. Use of soil and leaf testing (one test per year). Reduction in fertiliser rates (based on historical rates). Fertiliser applied less frequently and on a calendar basis. Spray equipment calibrated. Trash kept but left where it drops. Overhead sprinklers used for irrigation. Irrigation application varies with crop stage only with scheduling based on subjective tools.
C class to B class	Spray-out fallow with reduced cultivation. Fallow legume crop to improve soil health. Laser levelling used where appropriate. Use of soil and leaf testing on blocks to be planted. Reduced rate of fertiliser according to recommended rates. Shift towards the use of fertigation, banded surface application and soil ameliorants. Banana waste returned to paddock, leaf mulch kept on beds. Chemical application based on monitory and equipment calibrated. Reduction in the use of residual herbicides. Insecticides and fungicides application is based on monitoring. Irrigation scheduling based on tensiometers. Manually operated irrigation system under canopy irrigation.
B class to A class	Zonal tillage used for planting preparation, tillage only on the bed area. Fallow crop to improve soil health. Controlled traffic with machinery Soil and yield mapping. Soil and leaf testing on a regular basis. Slashing of inter row and ground cover maintained. Leaf mulch composted and returned to paddock. Use of knockdown herbicides instead on residuals. Automated drip irrigation with fertigation capacity and scheduling based on enviroscan. Monitoring of water quality.

4.2.1. Capital Costs

The capital costs incurred by any grower transitioning from one farming system to another will vary substantially. The capital costs that have been included in this economic analysis are shown in Table 26, although for each grower this list would be different.

Table 26: Capital Costs of practice change

Capital Item	*Cost ($)*
D class to C class:	
No capital investment	0
Total Investment	0
C class to B class:	
Rotational crop planter	15 000
*Fertigation equipment and filters	28 000
Slasher	10 500
Fertiliser box for banded application	35 000
*Monitoring equipment (pest & irrigation management)	8 521
*Under canopy irrigation	60 000
Total Investment	157 021
B class to A class:	
Zonal tillage equipment	25 000
Machinery Modifications for controlled traffic	60 000
Yield mapping	10 000
*Monitoring equipment (residual chemicals and enviroscan)	25 000
*Automated drip irrigation systems with fertigation	240 000
*Mapping Soil Types	10 000
Composting and spreader	50 000
Total Investment	420 000

* Data needs to be further validated to ensure that the figures are realistic and accurate.

In addition to the capital costs in Table 26, there are some annual costs associated with changing farming systems that are currently not taken into account with the gross margin calculations. These annual costs are associated with improvements in fertiliser application rates in B class and A class nutrient management. Annual costs associated with changing farming systems include:

- Soil tests: 4 soil tests per annum for C class management, 7 soil tests per annum for B class management and 12 soil tests per annum for A class management.
- Leaf tests: 7 leaf tests per annum for B class management and 12 leaf tests per annum for A class management.

4.2.2. Investment Analysis

An investment analysis has been undertaken to determine if the increases in farm operating profit are sufficient to justify the capital and other costs associated with changing farming systems. The investment analysis framework implicitly accounts for the opportunity cost of the extra capital investment involved.

A real discount rate of 7% (adjusted for inflation rate) has been used to convert the future cash flows of the Banana business to their present values (value in today’s dollar terms). This accounts for the generally large initial capital costs associated with making a change and the smaller but longer term benefits of the change over the life of the investment. The resultant NPV of future cash flows, and provides decision makers with a criterion for selecting investments. The net present values calculated in this work take into account the difference in farm operating profit of the different management classes and the capital and annual costs incurred in moving to the new management class.

A positive NPV implies that the investment earns a rate of return in excess of the opportunity cost of capital and the business will be better off over the period of analysis by the amount of the NPV if the investment is undertaken. On the other hand, a negative NPV for an investment indicates that the business will be worse off if the investment is made.

Table 27 shows the net present values associated with changing from one class to another class over both a 5 year and 10 year investment period. The NPV's are greater for the 10 year investment period due to the fact that the large capital costs are incurred at the beginning of the investment, but the smaller improvements in cash flow are received annually. Thus the longer the investment time period, the more years of increased cash flow to offset the initial capital investment. These results are based on the parameters outlined in the Section 2 of this report.

Table 27: Net present value analysis farming system transition

Change	*NPV – 5 year analysis*	*NPV – 10 year analysis*
D class to C class	$759,044	$1,300,233
C class to B class	$474,475	$925,185
B class to A class	$-422,748	$-424,707

The transition from D to C class farming systems is worthwhile proposition with a strongly positive NPV for both 5 and 10 year investment horizons. A benefit-cost ratio is not applicable in this particular case because no capital investment is required in order to make the transition. The transition from C to B class farming systems is worthwhile investment and displays a positive NPV for both 5 and 10 year investment horizons. The transition from B to A class farming system is not a worthwhile investment with the results indicating a negative NPV for both the 5 and 10 year investment horizon. The transition from B to A class farming systems displays a negative NPV due to the large capital investment associated with the change in irrigation system and reduction in whole of farm gross margin.

4.2.3. Risk Analysis

Risk analysis has been undertaken due to the uncertainty that surrounds future cash flows. These future cash flows can vary due to the variability in prices received and yields obtained from the banana crop. This work has used PiRisk to introduce stochastic properties (variability) into the analysis by specifying probabilistic distributions for the variables that are considered most important. The outcomes for the risk analysis are arranged as cumulative probability distribution curves. The risk analysis focuses on variability in output price and yields. Table 28 contains the probabilities and distributions used in the PI risk analysis.

Table 28: Distributions of price and yields

Cumulative Distribution	*Price*	*Plant yield Cartons/ha*	*Ratoon yield Cartons/ha*
Minimum	$10	637	1911
Poor	$12	1911	2230
Most likely	$20	2867	2867
Good	$28	3504	3823
Maximum	$35	4142	5416
Probabilities of:			
Poor	10%	10%	10%
Most likely	50%	50%	50%
Good	90%	90%	90%
Expected Value	$20.25	2740	3026

PiRisk was used to conduct 30,000 simulations of the whole farm gross margin with random values being chosen from the probability distributions for prices and yields of a banana production system. The total whole farm gross margin obtained from each of the thirty thousand simulations for each management class are plotted on the cumulative probability graph in Figure 3.

Figure 3: Distribution of whole farm gross margin

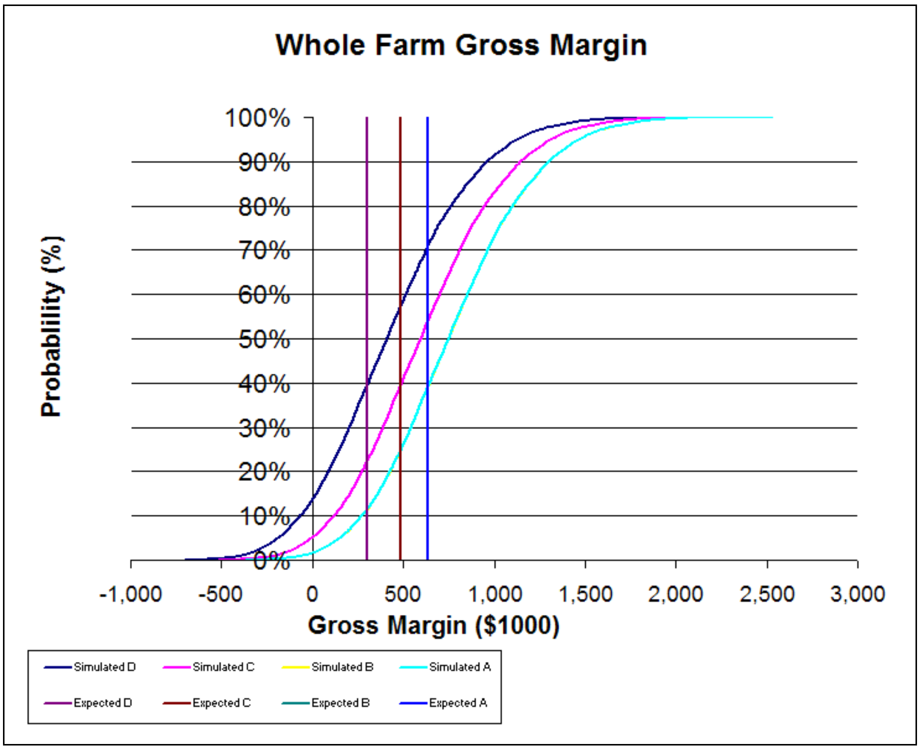


Figure 3 indicates that A and B class farming systems provide a very similar whole farm gross margin and are unable to be distinguished on the graph. The expected whole farm gross margin figures are based on the expected values for yield and price for Banana production (Table 28). The data presented in Figure 3 does not take into account fixed costs and the capital investment required when transitioning across the various farming systems.

5. DISCUSSION AND CONCLUSION

In this report we analyse implementation costs and benefits (productivity changes and or investment costs) for management practices, grouped into farming systems for water quality improvement, as defined in Van Grieken et al. (2010a). In order to do so, we compare paddock scale gross margins for the dominant agricultural production systems (sugarcane, grazing and banana cultivation) in the NRM regions Wet Tropics, Burdekin Dry Tropics and Mackay Whitsundays. Furthermore, where available, we present investment requirements for changing to improved farming systems. It must be noted that transaction costs are not captured within this project. Transaction costs refer to the indirect costs associated with changing from one system to another. For more information on transaction costs please refer to Coggan et al. (2010).

A few assumptions must be noted: The A class 'Aspirational' relates to proof of concept practices. All the information that is being presented on this class in this report is based on farming systems under research, which are scientifically sound but for which commercial viability has not yet been proven and caution must be taken with the interpretation of the actual numbers presented. Property gross margins are directly influenced by the size and equipment mix of the property. Interpretation of the results as gross margin per hectare may allow better comparison of enterprises operating under specific farming systems with other enterprises. However, the costs of operating machinery and presumably other fixed costs are also influenced by property size. Furthermore, enterprises operate in a social, financial and geographical heterogeneous environment and therefore the parameters and assumptions used in this economic analysis do not per se reflect each individual situation. Hence consideration of individual circumstances must be made in order to make an informed investment decision. It should also be acknowledged that the machinery operations, chemical applications and fertiliser applications reported in this project are only one of many possible scenarios that could equally suit each management class. In general, the results presented are one possible set of figures to show the changes in profitability while operating in different management classes. It is recommended that landholders that are willing to change management undertake their own research and analysis into the expected costs and benefits for their own soil types and property circumstances.

5.1. Sugarcane

Economic analysis of sugarcane has shown that there are expected benefits to sugarcane growers in the different regions through transitions to C and B class farming systems. The benefits will vary for each individual grower and will depend on their starting point and individual property scenario. A grower currently operating in a B class farming system may not be better off financially transitioning to an A class farming system, depending on the capital investment required and the length of the investment period. However, the costs and benefits associated with a transition will be different for each individual grower and therefore each circumstance needs to be carefully considered before making a change in management practice (see also Van Grieken et al. 2010b).

5.2. Grazing

Generally, reducing stocking rates come at a cost (reduced benefits) to grazing enterprises. However, when operating at low utilisation rates in wetter country, lowering stocking rates can potentially yield a benefit.

5.3. Bananas

The banana enterprise analysis indicates that the transition from D to C and C to B class management practices is a worthwhile proposition from an economic perspective for both the five and ten year investment horizon. The changing from D to C class management practices provided the greatest net present value benefit, followed by the transition from C to B class management practices. The results indicate that a change from B to A class farming systems is not worthwhile from a financial perspective. This is largely due to the large capital investment associated with the change in irrigation system and negative impact in whole of farm gross margin. The risk analysis showed that in any specific year the whole of farm gross margin will be higher when operating with an improved farming system, although the difference is small between B and A class farming systems. Overall, this economic analysis has shown that there are expected to be benefits to growers in the Tully region through transitions from D to C and C to B class farming systems, although the benefits will vary for each individual grower depending on their starting point and their individual property scenario.

It must be noted that the banana economic analysis is based on the assumptions outlined in Section 3.3.3, the management practices outlined in Section 3.3.5 and the capital costs outlined in Section 3.3.6. Limitations exist with some of the data used in the analysis and additional resources are required to validate these assumptions with industry to ensure they are realistic and accurate.

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