

Resource compilation

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Department of Agriculture and Fisheries

Measuring the profitability and environmental implications of adopting Best Management Practices on sugarcane farms in the Wet Tropics



Project Summary Fact-sheet



Case Study 1: SALMEC: North of Cairns (Freshwater)



Case Study 2: Doug Crees: Mossman



Case Study 3: Adrian Darveniza: Innisfail (South Johnstone)



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Case Study 5: Walter Giordani: Herbert region



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Related resources in the project funded by Sugar Research Australia (SRA project number 2014/015: Measuring the profitability and environmental implications when growers transition to Best Management Practices), including the individual case studies, project final report and literature review are available at <https://publications.qld.gov.au/dataset/best-management-practices-for-sugarcane>.

For further information about the project please contact the Department of Agriculture and Fisheries on 13 25 23. Publication dates in this compilation vary between individual resources.

This publication has been compiled by Caleb Connolly (editor) (Agricultural Economist), of Rural Economic Development, Department of Agriculture and Fisheries.

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Measuring the profitability and environmental implications of adopting Best Management Practices on sugarcane farms in the Wet Tropics

The economic and environmental impacts of adopting Best Management Practice (BMP)¹ have been considered for six sugarcane farms in the Wet Tropics (located near Ingham, Tully, Innisfail, Cairns and Mossman, and ranging in size from 90 to 830 ha). Each of the farms made a number of practice changes over time in the areas of soil health, nutrient management and pesticide management (and drainage improvements at some farms). The profitability and environmental performance of the farms before and after BMP adoption were evaluated using the Farm Economic Analysis Tool and the CaneLCA eco-efficiency calculator, based on farm management data provided by the growers.

Table 1—Examples of practice changes

Soil health
Increased row spacing (some with GPS guidance) and reduced tillage
Nutrient management
Adoption of Six Easy Steps recommendations and legume break crops
Pesticide management
Changes in the types of herbicide active ingredients applied, reduced herbicide applications and more precise applications

Image 1: Farm locations



Were the investments profitable?

Costs before and after BMP adoption were identified for each case study farm. The annual benefit² after BMP adoption was calculated to be positive for each farm, ranging between \$25 and \$220 per hectare per year (Table 1). The results indicate that the adoption of BMPs have added value to each farming business. The payback period calculated ranged between 2 years and 10 years. The economic benefits can be sensitive to changes in cane yields and some growers managed such risks through progressive implementation of the changes or co-investment to reduce capital costs.

Table 2—Investment analyses results³

	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6
<i>Farm size</i>	830 ha	167 ha	240 ha	150 ha	90 ha	760 ha
<i>Cost of implementation</i>	\$338,700	\$28,300	\$2,200	\$100,475	\$151,500	\$735,016
<i>Discounted payback period</i>	5 years	2 years	6 years	8 years	6 years	10 years
<i>Annual benefit \$/ha/yr</i>	\$101	\$100	\$58	\$25	\$220	\$57

¹ BMP, as defined by Smartcane BMP <https://www.smartcane.com.au/>.

² Annualised equivalent benefit (annual benefit) is calculated by taking into account the initial investment and the discounted annual change in gross margin aggregated over the life of the investment, which is then transformed into an annualised value.

³ For farms 3 and 5, cane yields were assumed to increase as a result of BMP adoption, based on the grower's historical production data or previous agronomic research. For the others, cane yields were assumed to remain the same.

What does this mean for the environment?

The environmental evaluation considered four indicators of environmental performance relating to water quality protection, fossil fuel use and greenhouse gas emissions over the life cycle of cane production. The results (Table 2) show that BMP adoption can reduce the potential for water quality impacts, due to less potential for nutrients and pesticides losses as a result of reduced application rates. The reduced fossil fuel use and greenhouse gas emissions are due to less diesel fuel use as a result of reduced tractor movements, but also from less fertilisers being produced in the factory. The amount of avoided greenhouse gases from each farm can be as high as taking 86 cars off the road, but more moderate for other farms. These environmental improvements were found to be quite resilient to the risk of cane yield changes.

Table 3—Reductions in environmental impacts for the case study farms

	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6
<i>Eutrophication potential from nutrient losses to water - PO₄-eq/t cane</i>	18%	17%	17%	31%	31%	2%
<i>Eco-toxicity potential from pesticide losses to water - CTUe /t cane</i>	44%	78%	48%	-9%	22%	53%
<i>Fossil fuel use - oil-eq/t cane</i>	10%	18%	21%	14%	18%	10%
<i>Greenhouse gas emissions - CO₂-eq/t cane</i>	17%	19%	23%	15%	20%	7%

What's the bottom line?

The results suggest that BMP changes in the Wet Tropics can provide both better farm profitability and better environmental performance. In some case studies, economic benefits were sensitive to an increase or decrease in cane yields and it is suggested that before making changes, growers take steps to manage risks (for example, by looking into agronomic research and their individual circumstances). The whole-of-farming system approach taken in the case studies meant that the impact of BMP changes on economic, environmental, agronomic and social factors could be considered and how changing one part of a farming system would affect the other parts of the farming system (reducing the potential for “tunnel vision” when looking at the impact of practice changes).

The results should not be used for the purposes of comparing farms, as each farming business is unique and the situations before and after BMP changes are made are different for each farm. Individual circumstances must be considered before applying the case studies to other situations.

For more information

The case studies were part of a project funded by Sugar Research Australia (SRA project number 2014/015 - Measuring the profitability and environmental implications when growers transition to Best Management Practices). Details of the individual case studies can be found in the case study reports, available at <https://publications.qld.gov.au/dataset/best-management-practices-for-sugarcane>.

For further information about the project please contact the Department of Agriculture and Fisheries on 13 25 23. This publication is an updated version of the fact-sheet.

The impact of Smartcane BMPs on business and the environment in the Wet Tropics

Case Study 1: Salmec

This case study is the first in a series that evaluates the economic and environmental impact of Smartcane Best Management Practice (BMP) adoption by a number of sugarcane growers in the Wet Tropics of North Queensland. Economic, biophysical and farm management data before and after BMP adoption was supplied by the grower and the Farm Economic Analysis Tool (FEAT)¹ and CaneLCA Eco-efficiency Calculator (CaneLCA)² were used to determine the impact of these changes on business performance and the environment. The findings of these case studies are specific to the individual businesses evaluated and are not intended to represent the impact of Smartcane adoption more broadly.

Key Findings of the Salmec case study

The transition to BMP, which began in 2008, has resulted in:

- Annual improvement in farm operating return of \$150/ha (\$124,500/yr total)
- 121kg less pesticide active ingredients and 1 tonne less nitrogen lost to waterways annually
- Annual fossil fuel use reduced by 10 per cent (or 30 tonnes of fuel over the cane life cycle)
- Greenhouse gas emissions reduced by 17 per cent annually (equivalent to taking 86 cars off the road each year).

About the farm

Salmec, owned and operated by Mark Savina and Mick Andrejic, manages 12 cane farms with a total area of 830 hectares north of Cairns. As part of their farming operations, Salmec plants and harvests its own cane. Over the past eight years, Salmec has implemented a range of changes to improve the profitability and reduce the environmental impact of their farms. Today, Salmec is a Smartcane BMP accredited business.

Image 1: Mark Savina



What changes were made?

Salmec has made big changes to nutrient, soil health and pest management (Table 1).

To reduce compaction and improve soil health, Salmec changed their row spacing to match the wheel tracks on their harvester. This meant moving from 1.52m to 1.8m row spacing using GPS guidance. Flipper-rollers were put on their harvesters to keep haulouts to the controlled traffic lanes. It took five years to make these changes across all blocks on each farm.

¹ FEAT is a Microsoft Excel[®] based tool that models sugarcane farm production from an economic perspective, allowing users to record and analyse revenues and costs associated with their sugarcane production systems. <https://www.daf.qld.gov.au/plants/field-crops-and-pastures/sugar/farm-economic-analysis-tool>.

² CaneLCA is a Microsoft Excel[®] based tool that calculates 'eco-efficiency' indicators for sugarcane growing based on the life cycle assessment (LCA) method. It streamlines the complex LCA process to make it more accessible to researchers, agricultural advisors, policy makers and farmers. <https://eshop.uniquet.com.au/canelca/>

To improve nutrient management, Salmec adopted the Six-Easy-Steps guidelines. Nitrogen rates recommended by Six-Easy-Steps were 50kg/ha less nitrogen in plant and ratoon cane than Salmec's standard practice.

Salmec made minor modifications to their chemical store and adopted Farmworks for electronic farm record keeping.

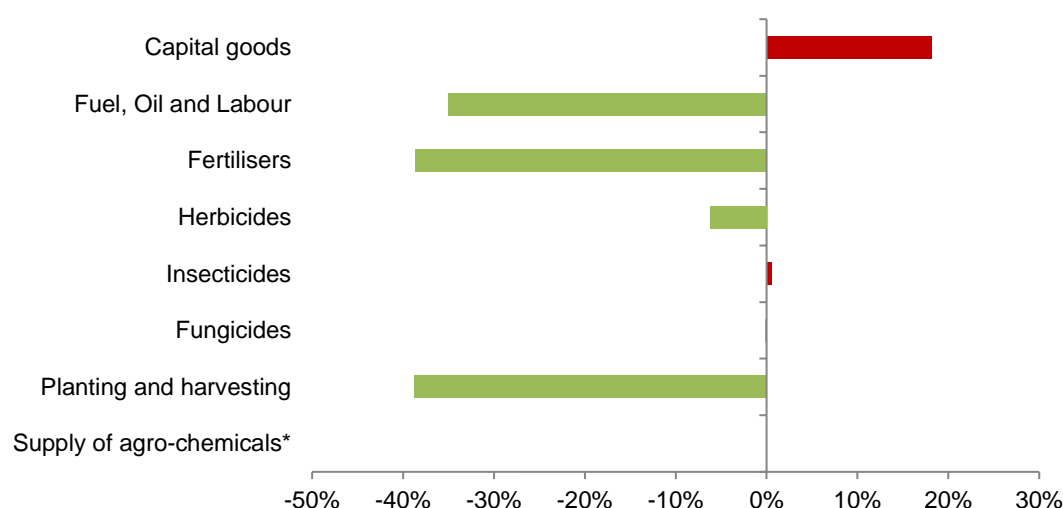
Table 1: Main changes to the new farming system

	Before	After
Weed, Pest and Disease Management	<ul style="list-style-type: none"> 3kg/ha Velpar K4 (468g/kg Diuron and 132g/kg Hexazinone) in plant and ratoon cane No insecticide 	<ul style="list-style-type: none"> Banded spraying in plant cane (30 per cent of time) No Diuron in plant and reduced Diuron in ratoon cane Reduced 2,4-D in plant and ratoon cane Insecticide - Talstar
Soil Health	<ul style="list-style-type: none"> Heavy tillage 1.52m row spacing Legume fallow (50 per cent of fallow area) 	<ul style="list-style-type: none"> Reduced tillage (zonal ripping and tillage) 1.8m single row spacing GPS guidance Legume fallow with preformed mounds (50 per cent of fallow area)
Nutrient Management	<ul style="list-style-type: none"> Grower determined nutrient rate 	<ul style="list-style-type: none"> Six-Easy-Steps nutrient rate

What does this mean for the business?

Economic analysis indicates that Salmec's operating return has increased by \$150/ha/yr (\$124,500/yr total) under the new BMP farming system. This is the result of lower operating costs after BMP adoption. The biggest contributors to change in operating costs were; fertiliser costs (-38 per cent, -\$58/ha); fuel, oil and labour (-35 per cent, -\$52/ha); planting and harvesting costs (-39 per cent, -\$58/ha); and capital goods costs (+18 per cent, \$27/ha) (Figure 1).

Figure 1: Contribution to change in farm operating costs (%)



*Cost to supply agro-chemicals is embodied in fertilisers /herbicide /insecticide /fungicide cost.

In terms of cost savings from BMP adoption, the \$52/ha reduction in money spent on fuel, oil and labour was mainly due to the wider row spacing, which reduces tractor hours through the reduction of the total number of rows and therefore distance travelled. For the same reason, fuel and labour used in harvesting was also reduced after BMP adoption. In addition, through adoption of Six-Easy-Steps nutrient program, money spent on fertiliser was reduced by \$58/ha.

Capital goods (Figure 1) refer to the cost of repairs, maintenance and depreciation of machinery and equipment. After BMP adoption repairs and maintenance costs decreased as a result of reduced tractor hours and zonal ripping. However, depreciation increased due to new machinery and equipment purchased to implement BMP.

How much did it cost to make the change?

To move to a controlled traffic system with 1.8m single row spacing, Salmec installed a GPS base station and purchased six GPS units. Modifications were made to widen implements, two flipper rollers were purchased for Salmec's harvesters and earthworks were undertaken to widen drains. Salmec also purchased a stool splitter, mound planter and spray boom. Chemical store modifications and the purchase of Farmworks software were relatively minor expenses.

The total cost of implementation was \$408/ha or \$338,700 across all 12 farms.

Was the investment profitable?

Results of an investment analysis show that BMP adoption was a worthwhile investment for Salmec. It would take five years to repay the \$338,700 invested. Over a ten year investment horizon, Salmec's investment has added an additional \$101/ha/yr to the bottom line (when the initial investment is taken into account) (Table 2). This analysis is based on the assumption that yield is maintained after BMP adoption, which is Salmec's experience.

Table 2: Total cost change, capital investment and value of investment

Cost of Implementation (\$/ha)	\$408
Discounted Payback Period	5 years
Annual Benefit (\$/ha/yr)	\$101
Internal Rate of Return	29 %
Investment Capacity (\$/ha)	\$1,204

Investment capacity is the maximum amount of money that can be spent before an investment becomes unprofitable. Salmec could have invested up to \$999,320 (\$1,204/ha), or three times their actual investment, before the cost savings made by adopting BMP would be insufficient to provide the required (7 per cent) return on investment.

What does this mean for the environment?

The environmental impacts of Salmec's farming system before and after BMP adoption are shown in Figure 2.

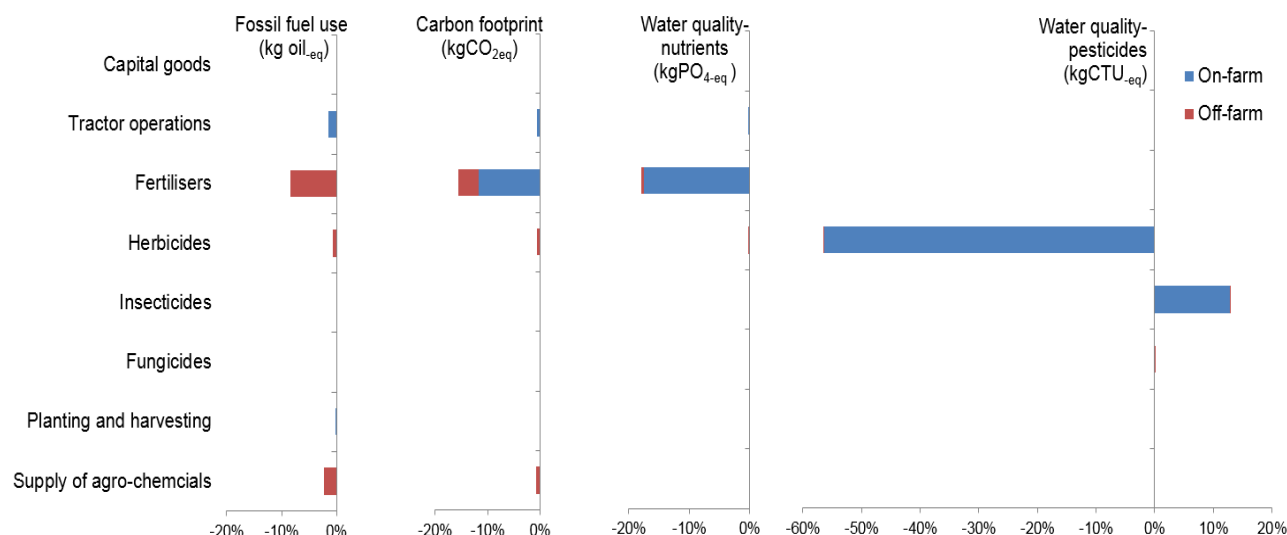
After BMP adoption, annual fossil-fuel use was reduced by 10 per cent overall. This means avoiding around 30 tonnes of fossil fuel use per year for the whole life cycle of the farming operation³. More than half of this occurs off-farm, due to less fertiliser being produced at the factory and supplied to the farm. Avoided urea production is the biggest energy-saver because it's an energy-intensive fertiliser, but there are also some savings from other fertiliser ingredients (DAP, KCl, Gran-am). The remainder is due to Salmec's own on-farm reduction in fuel use for tractor operations, planting and harvesting as a result of wider row spacing.

The carbon footprint (greenhouse gas emissions) of cane production reduced by 17 per cent overall after BMP adoption. This means avoiding around 266 tonnes of carbon dioxide per year across the whole farming operation, the equivalent of taking 86 cars off the road for a year. Most of the carbon

³ Life cycle fossil fuel use includes not just the diesel consumed directly on the farm but also the fossil fuels used in the production the fertilisers, pesticides, lime, electricity etc. used on the farm.

footprint reduction (77 per cent) is due to less on-farm emissions of nitrous oxide⁴ (a strong greenhouse gas) due to Salmec reducing the use of nitrogen fertiliser. The rest (23 per cent) are due to the avoidance of off-farm production and supply of fertilisers (mostly urea), as well as less tractor and harvester fuel from the wider row spacing.

Figure 2: Increase / decrease in environmental impacts after adoption of BMP (per ha)⁵



The potential for water eutrophication from losses of nutrients to the environment was estimated to reduce by 18 per cent overall. This means the avoidance of around 1 tonne of eutrophying substances being lost to water per year across the whole farming operation. This is all due to a reduced potential for nitrogen loss to surface water runoff and groundwater infiltration, because less nitrogen has been applied.

The potential for aquatic eco-toxicity impacts from losses of pesticides to water was estimated to reduce by 44 per cent overall. This resulted from an avoided loss of around 121kg of pesticide active ingredients to water per year. Reduced herbicide application rates for active ingredients with higher toxicity potential (atrazine, diuron, hexazinone, paraquat and pendimethalin) contributed to a 56 per cent impact reduction, but there is a potential increase in impact (11 per cent) due to the introduction of the insecticide Talstar (bifenthrin) in Salmec's new farming system.

What about risk?

When adopting any management practice change there is always a risk that things may not go as planned (e.g. yield loss, financial risk). The adoption of management practices that have been

⁴ The assessment assumes a generic nitrous oxide (N₂O) emission factor of 1.99% of applied N lost as nitrous oxide N, which is based on the latest Australian greenhouse gas inventory methodology. The global warming potential for nitrous oxide is 298 kg CO₂-e / kg N₂O.

⁵ A negative value is a decrease in environmental impact, and a positive value is an increase in impacts.

kg oil-eq = kilograms of oil equivalent, the reference substance for measuring fossil-fuel resource depletion

kg CO₂-eq = kilograms of carbon dioxide equivalent, the reference substance for measuring greenhouse gases

kg PO₄-eq = kilograms of phosphate equivalent, the reference substance for measuring eutrophication of water due to releases of nutrients (N, P) and sugar

kg CTU-eq = kilogram of equivalent critical toxicity units, a measure of eco-toxicity in freshwater due to releases of pesticides

scientifically validated, such as BMP, means that an adverse impact on production is unlikely.

Results of a production risk analysis show that yield across plant and ratoon cane would need to decline by more than 7 per cent before investing in BMP adoption is unprofitable for Salmec (Figure 3).

From an environmental perspective, the yields across plant and ratoon canes would need to decline by between 20 per cent and 25 per cent for there to be no net gains in life cycle fossil fuel use, carbon footprint, and nutrient-related water quality impacts; and by 45 per cent for there to be no net gains in pesticide-related water quality impacts (Figure 4).

What's the bottom line?

This case study has evaluated the business and environmental impact of Smartcane BMP adoption for a farm in the Wet Tropics.

Results indicate that BMP adoption has resulted in a large cost saving for Salmec by reducing the amount spent on fertiliser, fuel and labour. Salmec made a significant investment in new machinery and equipment to implement BMP and this has proved to be a worthwhile investment.

The most significant environmental benefit for Salmec is the reduced potential for water quality impacts from a transition to pesticide with lower toxicity, residuals not applied in the wheel tracks and reduced application rates, and a reduction in the amount of N fertiliser applied. There are also fossil-fuel conservation and greenhouse gas mitigation gains from a combination of increased row spacing and reduced urea demand.

Each farming business is unique in its circumstances and therefore the parameters and assumptions used in this case study reflect Salmec's situation only. Consideration of individual circumstances must be made before applying this case study to another situation.

Figure 3: Annual benefit of investment (\$/ha/yr) sensitivity to yield

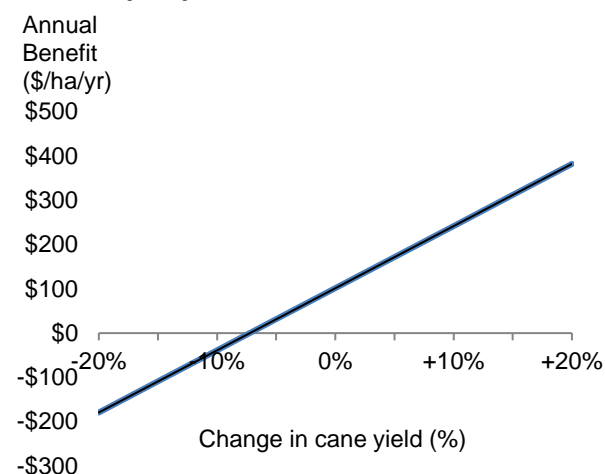
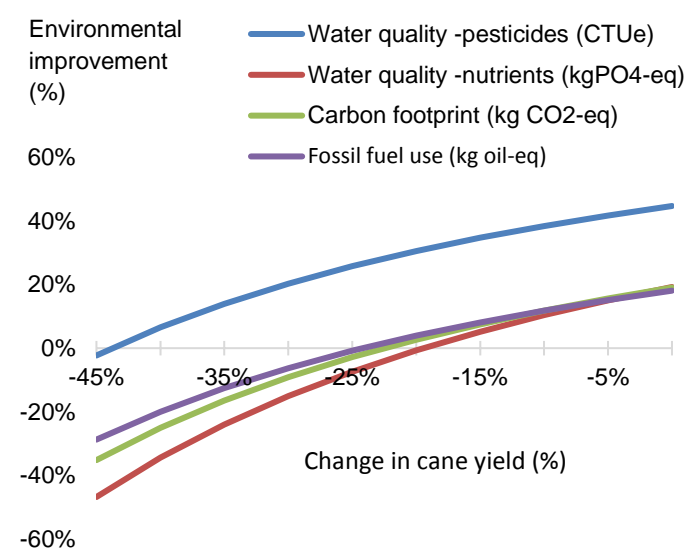


Figure 4: Environmental impact sensitivity to yield



This case study forms a component of SRA Project 2014/15 (Measuring the profitability and environmental implications when growers transition to Best Management Practices). For further information contact the Townsville DAF office on (07) 3330 4560. This publication is an updated version of the case study.

The impact of Smartcane BMPs on business and the environment in the Wet Tropics

Case Study 2: Doug Crees

This case study is the second in a series that evaluates the economic and environmental impact of Smartcane Best Management Practice (BMP) adoption by a number of sugarcane growers in the Wet Tropics of north Queensland. Economic, biophysical and farm management data before and after BMP adoption was supplied by the grower, and the Farm Economic Analysis Tool (FEAT)¹ and CaneLCA Eco-efficiency Calculator (CaneLCA)² were used to determine the impact of these changes on business performance and the environment. The findings of these case studies are specific to the individual businesses evaluated and are not intended to represent the impact of Smartcane adoption more broadly.

Key findings of the Doug Crees case study

The transition to BMP, which began in 2004, has resulted in:

- Annual improvement in farm operating return of \$109/ha (\$16,542/yr total)
- 9kg less pesticide active ingredients and 650kg less nitrogen lost to waterways annually
- Annual fossil fuel use reduced by 18 per cent (or 14 tonnes of fuel over the cane life cycle)
- Greenhouse gas emissions reduced by 19 per cent annually (equivalent to taking 40 cars off the road each year).

About the farm

Doug Crees farms 167 hectares of sugar cane in Mossman, far north Queensland. Doug plants his own cane and uses a contractor for harvesting. Doug grows a legume fallow in rotation to sugarcane.

Over the past twelve years, Doug has implemented a range of best management practices on his farm to improve profitability and reduce his environmental impact.

Image 1: Doug Crees



What changes were made?

The main changes to Doug's farming system are summarised in Table 1.

Doug changed his row spacing from 1.52m to 1.68m using GPS guidance. In Doug's experience, 1.68m row spacing has allowed better alignment to the wheel tracks on his tractors without the earthworks needed to move wider equipment around his farm. It took Doug seven years to make these changes across his entire farm.

¹ FEAT is a Microsoft Excel[®] based tool that models sugarcane farm production from an economic perspective, allowing users to record and analyse revenues and costs associated with their sugarcane production systems. <https://www.daf.qld.gov.au/plants/field-crops-and-pastures/sugar/farm-economic-analysis-tool>.

² CaneLCA is a Microsoft Excel[®] based tool that calculates 'eco-efficiency' indicators for sugarcane growing based on the life cycle assessment (LCA) method. It streamlines the complex LCA process to make it more accessible to researchers, agricultural advisors, policy makers and farmers. <https://eshop.uniquet.com.au/canelca/>

To improve nutrient management, Doug adopted the Six-Easy-Steps guidelines. Under a soybean fallow, nitrogen rates recommended by Six-Easy-Steps were 115kg/ha less nitrogen in plant cane and 27kg/ha less nitrogen in ratoons than Doug's original practices.

In fallow, Doug reduced his tillage operations by using a direct drill legume planter and replaced his cowpea cover crop with soybeans. Additional changes made by Doug include; ceasing diuron and atrazine application in plant cane and minor chemical store modifications.

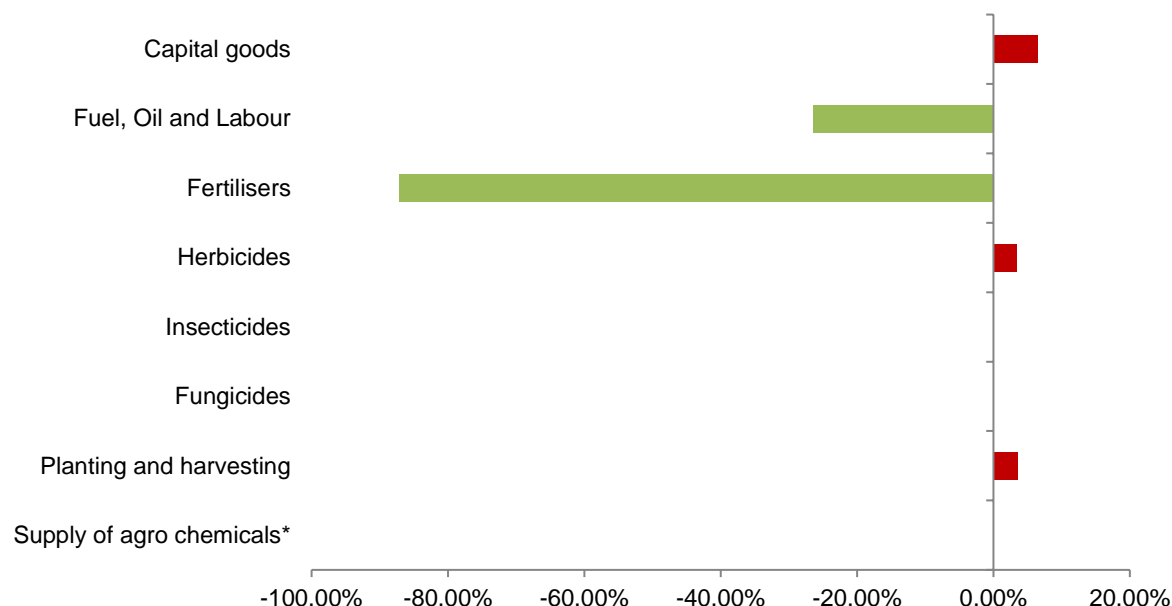
Table 1: Main changes to the new farming system

	Before	After
Weed, Pest and Disease Management	<ul style="list-style-type: none"> 3kg/ha Velpar K4 (468g/kg diuron and 132g/kg hexazinone) in plant cane 1L/ha Gesaprim (900g/kg atrazine) in plant cane 	<ul style="list-style-type: none"> No diuron in plant cane No atrazine in plant cane Balance (750g/kg isoxaflutole) in plant cane
Soil Health	<ul style="list-style-type: none"> Heavy tillage (discing, ripping and rotary hoe) 1.52m row spacing Cow pea fallow crop 	<ul style="list-style-type: none"> Reduced tillage (zonal ripping, no rotary hoe) 1.68m row spacing GPS guidance Soy fallow crop using direct drill
Nutrient Management	<ul style="list-style-type: none"> Grower determined nutrient rate 	<ul style="list-style-type: none"> Six-Easy-Steps nutrient rate in plant cane and ratoons

What does this mean for the business?

Economic analysis indicates that Doug's operating return has increased by \$109/ha/yr (\$16,542/yr total) under the new BMP farming system. This is the result of lower operating costs after BMP adoption. The biggest contributors to change in operating costs were; fertiliser costs (-87 per cent, -\$95/ha); fuel, oil and labour (-26 per cent, -\$29/ha); and capital goods (+6 per cent, \$7/ha) (Figure 1).

Figure 1: Contribution to change in farm operating costs (%)



*Cost to supply agro-chemicals is embodied in fertilisers /herbicide /insecticide /fungicide cost.

In terms of cost savings from BMP adoption, reduction in fertiliser use has had a significant impact. Through adoption of the Six-Easy-Steps nutrient program, Doug now spends \$95/ha less on fertiliser.

Reduced tillage has also made a large contribution to cost savings. Doug now spend \$29/ha less on fuel, oil and labour. Wider row spacing, which reduces tractor hours through the reduction of the total number of rows and therefore distance travelled, has also contributed to cost savings.

Overall, cost savings have more than offset cost increases. In this instance Doug has incurred a small cost increase in fallow, owing to the per hectare cost of soybeans being more than the per hectare cost of cowpea (per hectare cost being a product of the plant rate and seed cost) (Figure 1, planting and harvesting cost, \$4/ha). There has also been a small increase in herbicide costs (\$4/ha) resulting from the transition to pesticides with lower toxicity.

Capital goods (Figure 1) refer to the cost of repairs, maintenance and depreciation of machinery and equipment. After BMP adoption repairs and maintenance costs decreased as a result of reduced tractor hours. However, depreciation increased due to new equipment purchased. Consequently, Doug has incurred a small increase in capital goods costs.

How much did it cost to make the change?

To move to a controlled traffic minimal till system with 1.68m single row spacing, Doug purchased a GPS unit, converted his ripper to a zonal ripper and made modifications to his mechanical weeder. Doug borrowed a direct drill legume planter at no cost.

The total cost of implementation was \$186/ha or \$28,300.

Was the investment profitable?

Results of an investment analysis show that BMP adoption was a worthwhile investment. It would take two years to repay the \$28,300 invested. Over a ten year investment horizon, Doug's investment has added an additional \$100/ha/yr to the bottom line (when the initial investment is taken into account) (Table 2). This analysis is based on the assumption that yield is maintained after BMP adoption, which is Doug's experience.

Table 2: Total cost change, capital investment and value of investment

Cost of Implementation (\$/ha)	\$186
Discounted Payback Period	2 years
Annual Benefit (\$/ha/yr)	\$100
Internal Rate of Return	66%
Investment Capacity (\$/ha)	\$886

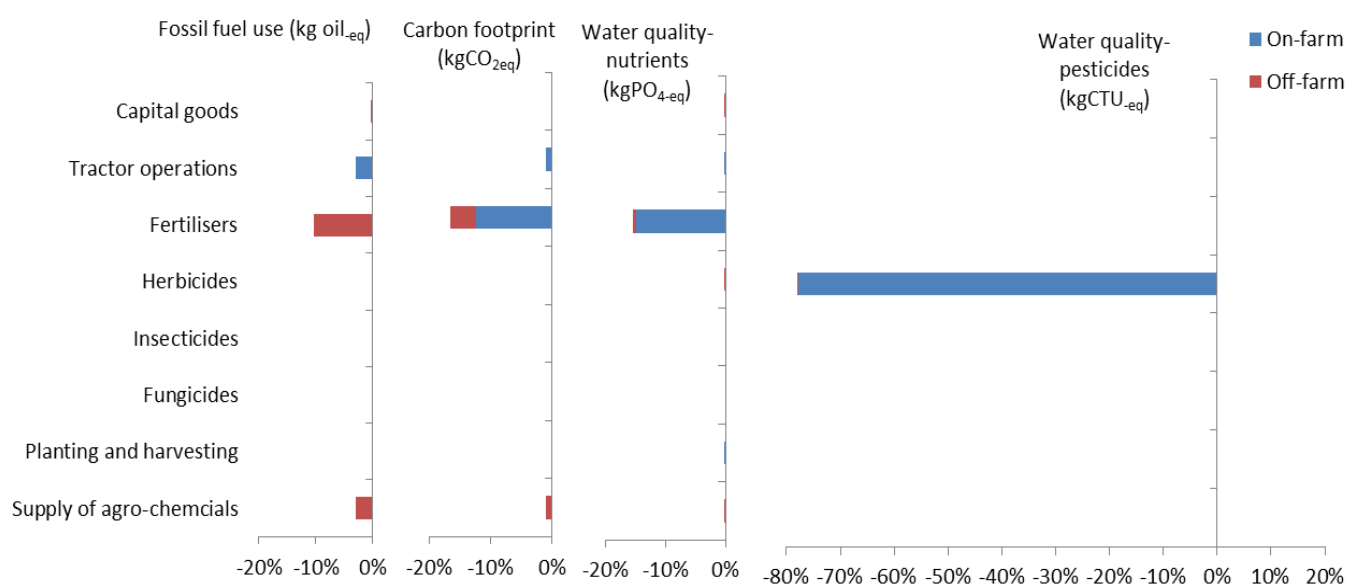
Doug could have invested up to \$134,654 (\$886/ha), or more than four times his actual investment, before the cost savings made by adopting BMP would be insufficient to provide the required (7 per cent) return on investment (Table 2, Investment capacity).

What does this mean for the environment?

The estimated environmental impacts of Doug's farming system before and after BMP adoption are shown in Figure 2.

After BMP adoption, annual fossil-fuel use was reduced by 18 per cent overall. This means avoiding around 14 tonnes of fossil fuel use per year over the whole life cycle of the farming operation³. More than half of this occurs off-farm, due to less fertiliser being produced at the factory and supplied to the farm. Avoided urea use is the biggest energy-saver because its production is energy intensive, but there are also some savings from reduced potassium fertiliser use. The remainder is due to the on-farm reductions in fuel use for tractor operations as a result of reduced tillage and wider row spacing.

³ Fossil fuel use over the whole life cycle of the farming operation includes not just on-farm diesel consumption but also off-farm use of fossil fuels in the production of fertilisers, pesticides, lime, electricity.

Figure 2: Increase / decrease in environmental impacts after adoption of BMP (per ha)⁴

The carbon footprint (greenhouse gas emissions) of cane production is reduced by around 19 per cent overall after BMP adoption. This means avoiding around 123 tonnes of carbon dioxide per year across the whole farming operation, the equivalent of taking 40 cars off the road for a year. Most of the carbon footprint reduction (75 per cent) is due to less on-farm emissions of nitrous oxide⁵ (a strong greenhouse gas) due to the reduced nitrogen application rates. The rest (25 per cent) are due to the avoidance of off-farm production and supply of fertilisers (mostly urea), as well as less tractor use from reduced tillage and wider row spacing.

The potential for water eutrophication from nutrient losses to the environment was estimated to reduce by around 17 per cent. This means the avoidance of around 650kg of eutrophying substances lost to waterways per year. This is all due to a reduced potential for nitrogen loss to surface water runoff and groundwater infiltration, because less nitrogen has been applied.

The potential for aquatic eco-toxicity impacts from losses of pesticides to waterways was estimated to reduce by 78 per cent overall. This resulted from an avoided loss of around 9kg of pesticide active ingredients to water, as well as a change to active ingredients with less toxicity.

What about risk?

When adopting any management practice change there is always a risk that things may not go as planned (e.g. yield loss, financial risk). The adoption of management practices that have been scientifically validated, such as BMP, means that an adverse impact on production is unlikely.

⁴ A negative value is a decrease in environmental impact, and a positive value is an increase in impacts.

kg oil_{eq} = kilograms of oil equivalent, the reference substance for measuring fossil-fuel resource depletion

kg CO_{2eq} = kilograms of carbon dioxide equivalent, the reference substance for measuring greenhouse gases

kg PO_{4eq} = kilograms of phosphate equivalent, the reference substance for measuring eutrophication of water due to releases of nutrients (N, P) and sugar

kg CTU_{eq} = kilogram of equivalent critical toxicity units, a measure of eco-toxicity in freshwater due to releases of pesticides

⁵ The assessment assumes a generic nitrous oxide (N₂O) emission factor of 1.99% of applied N lost as nitrous oxide N, which is based on the latest Australian greenhouse gas inventory methodology. The global warming potential is 298 kg CO_{2-e}/kgN₂O.

Results of a production risk analysis show that yield across plant and ratoon cane would need to decline by more than 7 per cent before investing in BMP adoption is unprofitable (Figure 3).

From an environmental perspective, for there to be no net gains in environmental impacts (per tonne cane produced), yields across plant and ratoon canes would need to decline by 15 per cent for nutrient-related water quality impacts and 25 per cent for both fossil fuel use and carbon footprint. For pesticide-related water quality impacts, yield decrease would have to be considerable for there to be no net gain (Figure 4).

What's the bottom line?

This case study has evaluated the business and environmental impact of Smartcane BMP adoption for a farm in the Wet Tropics.

Results of the economic analysis indicate that BMP adoption has resulted in cost savings for Doug, largely as a result of reduced fertiliser application. The amount Doug now spends on fuel and labour has also reduced.

Doug invested in a GPS and made some minor machinery modifications to implement BMP. This has proved to be a worthwhile investment.

The most significant environmental benefit for Doug Crees' farm is the reduced potential for water quality impacts from a transition to pesticide with lower toxicity and a reduction in the amount of N fertiliser applied. There are also fossil-fuel conservation and greenhouse gas mitigation gains from a combination of reduced tillage and reduced urea demand.

Each farming business is unique in its circumstances and therefore the parameters and assumptions used in this case study reflect Doug Crees' situation only. Consideration of individual circumstances must be made before applying this case study to another situation.

This case study forms a component of SRA Project 2014/15 (Measuring the profitability and environmental implications when growers transition to Best Management Practices). For further information contact the Townsville DAF office on (07) 3330 4560. This publication is an updated version.

Figure 3: Annual benefit of investment (\$/ha/yr) sensitivity to yield

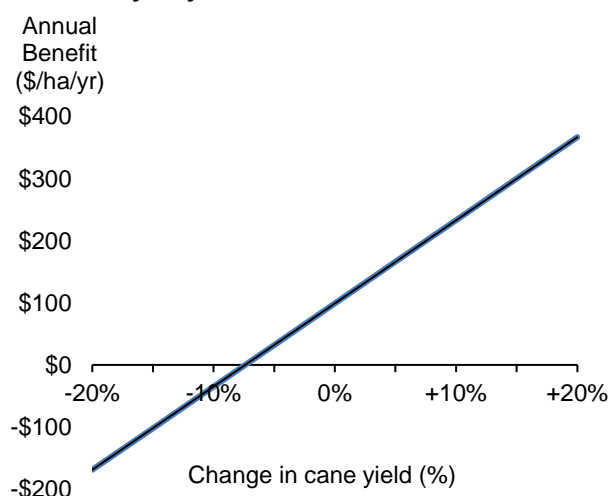
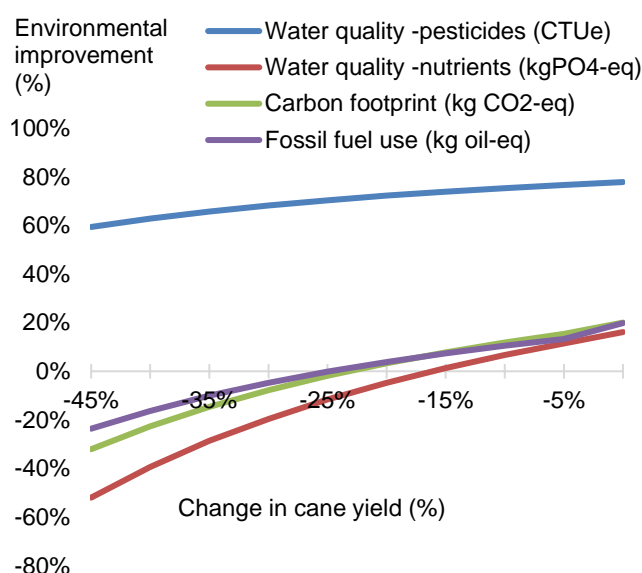


Figure 4: Environmental impact (impact/t cane) sensitivity to yield



The impact of Smartcane BMPs on business and the environment in the Wet Tropics

Case Study 3: Adrian Darveniza

This case study is the third in a series that evaluates the economic and environmental impact of Smartcane Best Management Practice (BMP) adoption by a number of sugarcane growers in the Wet Tropics of north Queensland. Economic, biophysical and farm management data before and after BMP adoption was supplied by the grower and the Farm Economic Analysis Tool (FEAT)¹ and CaneLCA Eco-efficiency Calculator (CaneLCA)² were used to determine the impact of these changes on business performance and the environment. The findings of these case studies are specific to the individual businesses evaluated and are not intended to represent the impact of Smartcane adoption more broadly.

Key findings of the Adrian Darveniza case study

The transition to BMP, which began in 2010, has resulted in:

- Annual improvement in farm operating return of \$160/ha (\$38,400/yr total)
- 41kg less pesticide active ingredients and 833kg less nitrogen and phosphorous lost to waterways annually
- Annual fossil fuel use reduced by 21 per cent (or 28 tonnes of fuel over the cane life cycle)
- Greenhouse gas emissions reduced by 23 per cent annually (equivalent to taking 67 cars off the road each year).

About the farm

Adrian Darveniza farms 240 hectares of sugar cane in South Johnstone, far north Queensland. Adrian plants his own cane using a whole-stick planter and uses a contractor for harvesting. Adrian took over as manager of the family farm in 2010 and over the past six years has implemented a range of best management practices. Today, Adrian is a Smartcane BMP accredited grower.

What changes were made? *Image 1: Adrian Darveniza*

The main changes to Adrian's farming system are summarised in Table 1.

To reduce compaction and improve soil health, Adrian widened his row spacing from 1.5m to 1.8m to match the wheel tracks on his contractor's harvester. Adrian has also moved away from a plough-out/replant cane system and now includes a bare fallow in rotation with cane.



¹ FEAT is a Microsoft Excel[®] based tool that models sugarcane farm production from an economic perspective, allowing users to record and analyse revenues and costs associated with their sugarcane production systems. <https://www.daf.qld.gov.au/plants/field-crops-and-pastures/sugar/farm-economic-analysis-tool>.

² CaneLCA is a Microsoft Excel[®] based tool that calculates 'eco-efficiency' indicators for sugarcane growing based on the life cycle assessment (LCA) method. It streamlines the complex LCA process to make it more accessible to researchers, agricultural advisors, policy makers and farmers. <https://eshop.uniquet.com.au/canelca/>

To improve nutrient management, Adrian adopted the Six-Easy-Steps guidelines. Nitrogen rates recommended by Six-Easy-Steps were 18kg/ha less nitrogen in plant cane and 47kg/ha less nitrogen in ratoons than previously applied. Adrian also adopted banded mill mud application in ratoon cane.

To improve weed management, Adrian, with assistance from the Department of Agriculture and Fisheries, converted his Irvin spray boom to a Dual Herbicide Sprayer (DHS). Adrian uses the DHS in ratoon cane which has resulted in reduced Diuron, Paraquat and 2,4-D application.

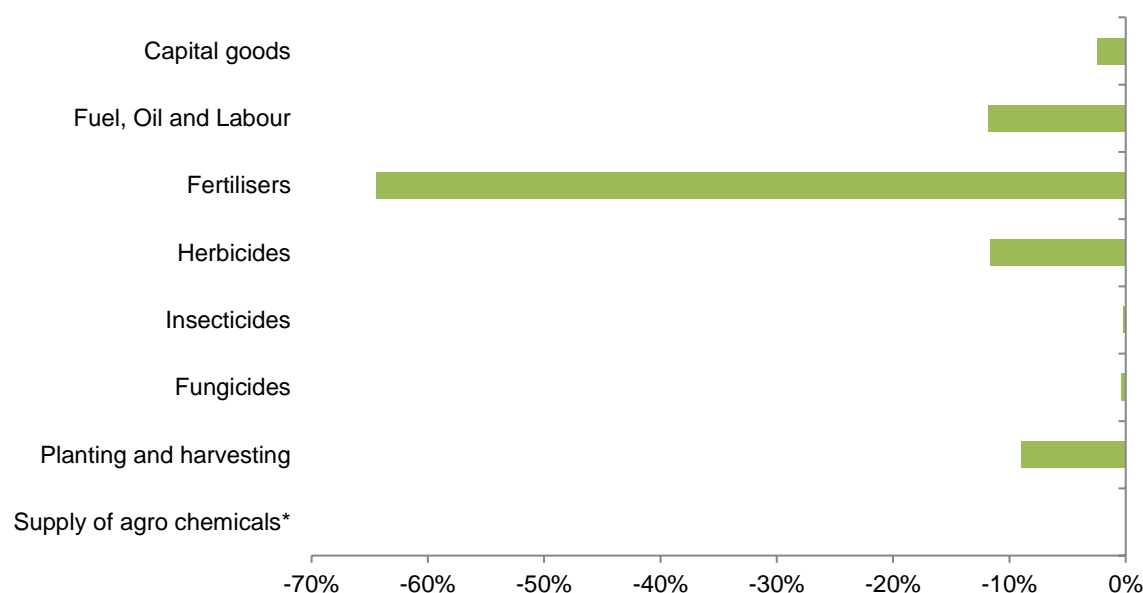
Table 1: Main changes to the new farming system

	Before	After
Weed, Pest and Disease Management	<ul style="list-style-type: none"> Irvin legs 	<ul style="list-style-type: none"> Dual herbicide sprayer – reduced herbicide application (Diuron, Paraquat and 2,4-D).
Soil Health	<ul style="list-style-type: none"> Plough-out/replant 1.5m row spacing 	<ul style="list-style-type: none"> Bare fallow 1.8m row spacing
Nutrient Management	<ul style="list-style-type: none"> Grower determined nutrient rate 	<ul style="list-style-type: none"> Six-Easy-Steps nutrient rate Banded mill mud application in ratoons

What does this mean for the business?

Economic analysis indicates that Adrian's operating return has increased by \$160/ha/yr (\$38,400/yr total) under the new BMP farming system. This is the result of lower operating costs after BMP adoption. The biggest contributors to change in operating costs were; fertiliser costs (-64 per cent, -\$103/ha); fuel, oil and labour (-12 per cent, -\$19/ha); herbicides (-12 per cent, -\$19/ha) and planting and harvesting (-9 per cent, \$14/ha) (Figure 1).

Figure 1: Contribution to change in farm operating costs (%)



*Cost to supply agro-chemicals is embodied in fertilisers /herbicide /insecticide /fungicide cost.

In terms of cost savings from BMP adoption, reduction in fertiliser use has had a significant impact. Through adoption of the Six-Easy-Steps nutrient program and bare fallow system which has reduced farm area under cane, Adrian now spends \$103/ha less on fertiliser. Cost savings made by a

reduction in synthetic fertiliser have more than offset the cost of mill mud, which in Adrian's case (due to banded application and Adrian's close proximity to the South Johnstone mill) is a cost effective alternative.

Wider row spacing, which reduces tractor hours through the reduction of the total number of rows and therefore distance travelled, has contributed to additional cost savings in fuel, oil and labour.

Herbicide costs were reduced as a result of greater herbicide application efficiency due to modification of Adrian's Irvin spray boom to a DHS.

Capital goods (Figure 1) refer to the cost of repairs, maintenance and depreciation of machinery and equipment. After BMP adoption repairs and maintenance costs decreased as a result of reduced tractor hours. As there was no investment in new capital, depreciation expenses remain the same both before and after BMP adoption.

How much did it cost to make the change?

The total cost of implementation was \$2,200 (\$9/ha) reflecting money spent on parts and Adrian's own labour to widen tractors and implements to move from a 1.5m to 1.8m row spacing. The DHS used in Adrian's new production system was constructed by modifying Adrian's existing Irvin spray boom with assistance from the Department of Agriculture and Fisheries.

Was the investment profitable?

Results of an investment analysis show that BMP adoption was a worthwhile investment. It would take six years to repay the \$2,200 invested, reflecting the transition from a plough-out/replant to fallow system in which reduced area under cane results initially in a loss of income before yield and income is gradually increased as a result of fallowing.

Over a ten year investment horizon, Adrian's investment has added an additional \$58/ha/yr to the bottom line (when the initial investment and required return of 7% is taken into account) (Table 2).

This analysis is based on the assumption that overall production is maintained after BMP adoption. Moving from a plough-out/replant to a bare fallow system has resulted in a loss of cane growing area, however research by Garside and Bell³ (2011) indicates that cane yield per hectare can increase considerably in response to a fallow period. It is therefore assumed that total farm production is maintained by a 20 per cent increase in yield across all crop classes.

Adrian could have invested up to \$99,868 (\$416/ha) before the cost savings made by adopting BMP would be insufficient to provide the required (7 per cent) return on investment (Table 2, Investment capacity).

Table 2: Total cost change, capital investment and value of investment

Cost of Implementation (\$)	\$2,200
Discounted Payback Period	6 years
Annual Benefit (\$/ha/yr)	\$58
Internal Rate of Return	33%
Investment Capacity (\$/ha)	\$416

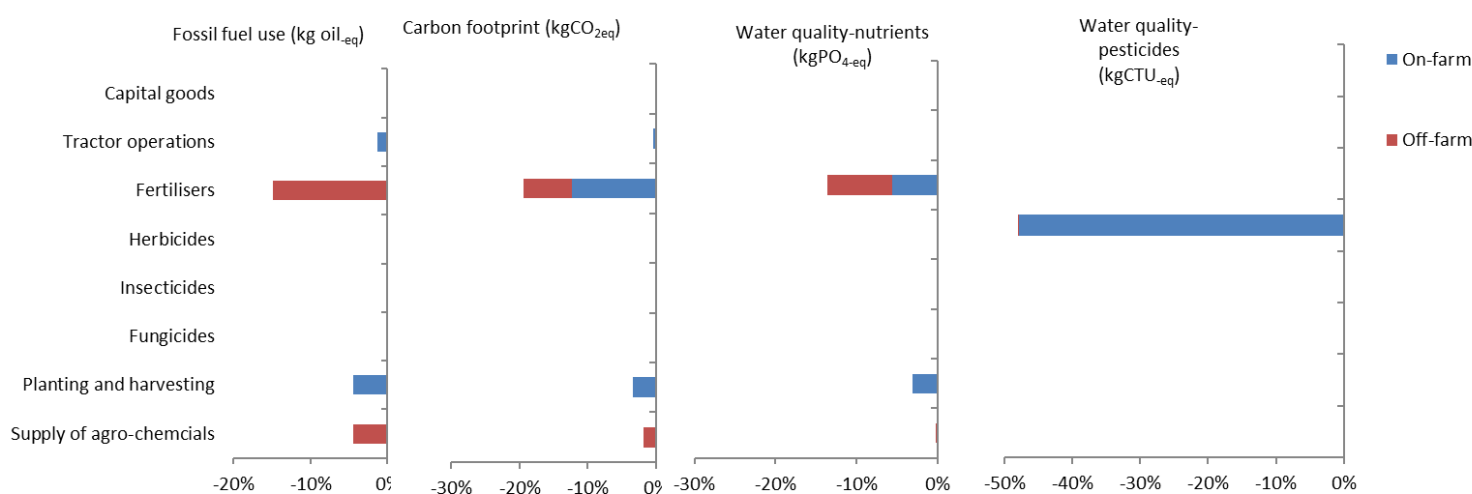
³ Garside, A.L. and Bell, M.J. (2011) Growth and yield responses to amendments to the sugarcane monoculture: effects of crop, pasture and bare fallow breaks and soil fumigation on plant and ratoon crops. *Crop and Pasture Science* 62(5), 396-412.

What does this mean for the environment?

The estimated change in environmental impacts for Adrian's farming system before and after BMP adoption are shown in Figure 2.

After BMP adoption, annual fossil-fuel use was reduced by 21 per cent overall. This means avoiding around 28 tonnes of fossil fuel use per year over the whole life cycle of the farming operation⁴. Most of this occurs off-farm, due to less fertiliser being produced at the factory and supplied to the farm. This is because Adrian now uses mill mud to provide some of the nutrient requirements. Avoided urea use is the biggest fossil fuel-saver because its production is energy intensive, but there are also some savings from reductions in the use of other fertiliser ingredients (DAP, KCl, Gran-am). The remainder of the fossil fuel savings are due to the slight reductions in on-farm fuel use for tractor and harvester operations as a result of the wider row spacing.

Figure 2: Increase / decrease in environmental impacts after adoption of BMP (per ha)⁵



The carbon footprint (greenhouse gas emissions) of cane production is reduced by 23 per cent overall after BMP adoption. This means avoiding around 205 tonnes of carbon dioxide per year across the whole farming operation, the equivalent of taking 67 cars off the road for a year. Around half of the carbon footprint reductions are due to less on-farm emissions of nitrous oxide⁶ (a strong greenhouse

⁴ Fossil fuel use over the whole life cycle of the farming operation includes not just on-farm diesel consumption but also off-farm use of fossil fuels in the production of fertilisers, pesticides, lime, electricity.

⁵ A negative value is a decrease in environmental impact, and a positive value is an increase in impacts.

kg oil-eq = kilograms of oil equivalent, the reference substance for measuring fossil-fuel resource depletion

kg CO₂-eq = kilograms of carbon dioxide equivalent, the reference substance for measuring greenhouse gases

kg PO₄-eq = kilograms of phosphate equivalent, the reference substance for measuring eutrophication of water due to releases of nutrients (N, P) and sugar

kg CTU-eq = kilogram of equivalent critical toxicity units, a measure of eco-toxicity in freshwater due to releases of pesticides

⁶ The assessment assumes a generic nitrous oxide (N₂O) emission factor of 1.99% of applied N lost as nitrous oxide N, which is based on the latest Australian greenhouse gas inventory methodology. The global warming potential is 298 kg CO₂-e/kg N₂O.

gas) from reductions in the amount of total nitrogen applied⁷. The rest are due to the avoidance of off-farm production and supply of fertilisers (mostly urea), less machinery use from the wider row spacing, and the fact that post-harvest trash burning of plough-out cane is no longer undertaken since Adrian moved away from a plough-out/replant system.

The potential for water eutrophication from nutrients losses to the environment was estimated to reduce by around 17 per cent. This means the avoidance of around 833kg of eutrophying substances (nitrogen and phosphorus) lost to water per year. This is due to a reduced potential for nitrogen and phosphorus loss to surface water runoff and groundwater infiltration, because less nitrogen and phosphorus has been applied⁸.

The potential for aquatic eco-toxicity impacts from losses of pesticides to water was estimated to reduce by 48 per cent overall. This is due to the avoided loss of around 41kg of pesticide active ingredients to water, because of slight reductions in the application rates of some herbicides, but mostly because the transition from a plough-out/replant system to a fallow system meant that there was less herbicide applied overall because of the reduced area under cane.

What about risk?

When adopting any management practice change there is always a risk that things may not go as planned (e.g. yield loss, financial risk). The adoption of management practices that have been scientifically validated, such as BMP, means that an adverse impact on production is unlikely.

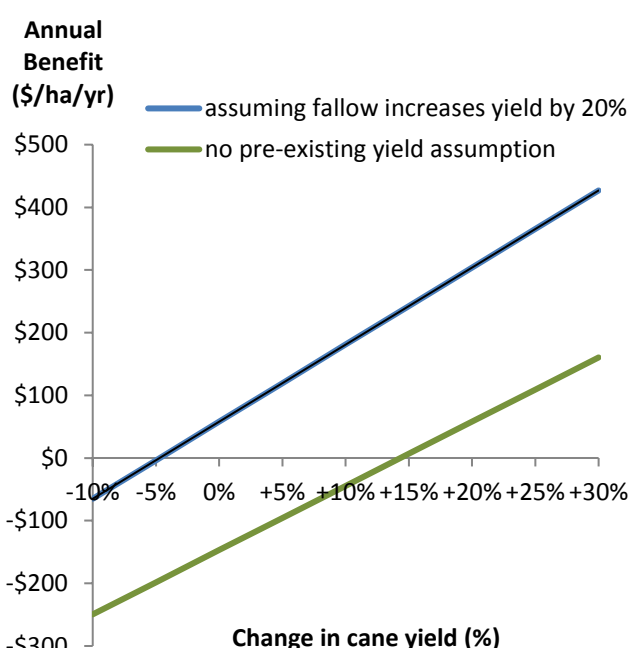
Results of a production risk analysis show that overall yield would need to decline by more than 4 per cent (when assuming the fallow period increases yield by 20%) before investing in BMP adoption is unprofitable (Figure 3).

From an environmental perspective, the outcomes are sensitive to both cane yield and the N and P content of the mill mud.

In relation to cane yields, for there to be no net gains in environmental impacts (per tonne of cane produced), yields across plant and ratoon canes would need to decline by 22 per cent for nutrient-related water quality impacts, 33 per cent for carbon footprint and 40 per cent for fossil fuel use. For pesticide-related water quality impacts, yield decline would have to be around 50 per cent for there to be no net gain (Figure 4).

This analysis was based on the assumption that the N and P content of mill mud are 0.075% and 0.065% wt/wt respectively; however the N and P content of mill mud can vary considerably. Results of

Figure 3: Annual benefit of investment (\$/ha/yr) sensitivity to yield



⁷ There is some uncertainty in this conclusion because the exact amount of nitrogen contained in the applied mill mud was not known. The sensitivity of our findings to this are considered in the 'What about the risk' section.

⁸ There is some uncertainty in this conclusion because the exact amount of nitrogen contained in the applied mill mud was not known. The sensitivity of our findings to this are considered in the 'What about the risk' section.

a sensitivity analysis show that if the N and P contents of the mill mud were actually around 0.1% there would be no improvement in water quality (Figure 5). If N and P contents are higher than 0.1%, there is a worsening in the potential for nutrient-related water quality impacts. The N content of mill mud also influences the carbon footprint (in relation to nitrous oxide emissions), however it is less sensitive. The N content of mill mud would need to be more than 0.4% for there to be no net improvement in carbon footprint.

What's the bottom line?

This case study has evaluated the business and environmental impact of Smartcane BMP adoption for a farm in the Wet Tropics.

Results of the economic analysis indicate that BMP adoption has been a profitable investment. Cost savings were made by reducing the amount spent on fertiliser, fuel, oil, labour and herbicides. Adrian made a relatively small investment to implement BMP. Transitioning to a fallow system has resulted in a gradual increase in profitability therefore increasing the likely payback period.

Transition from a plough-out/replant system to a fallow system has resulted in less overall herbicide application and a significant reduction in the potential for aquatic eco-toxicity impacts from losses of pesticides. Additional environmental benefits from the transition to BMP are reduced fossil fuel use, reduced greenhouse gas emissions and reduced potential for water eutrophication from nutrients losses as a result of reduction in fertiliser.

Each farming business is unique in its circumstances and therefore the parameters and assumptions used in this case study reflect Adrian's situation only. Consideration of individual circumstances must be made before applying this case study to another situation.

This case study forms a component of SRA Project 2014/15 (Measuring the profitability and environmental implications when growers transition to Best Management Practices). For further information contact the Townsville DAF office on (07) 3330 4560

Figure 4: Environmental impact (impact/t cane) sensitivity to yield

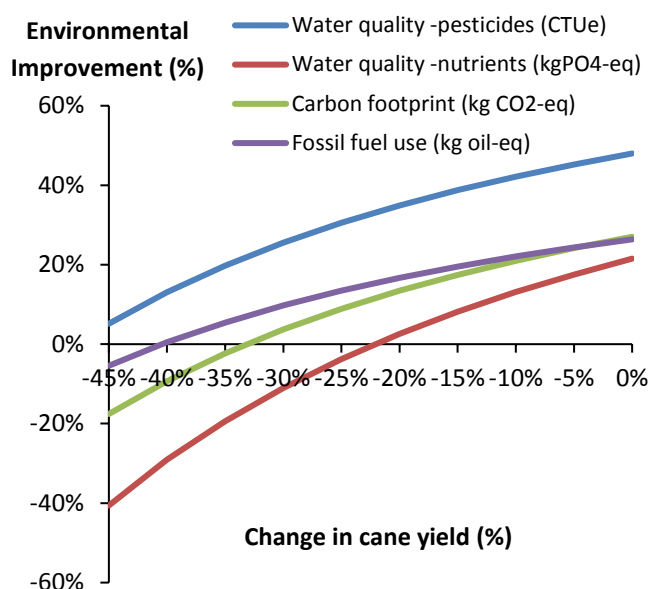
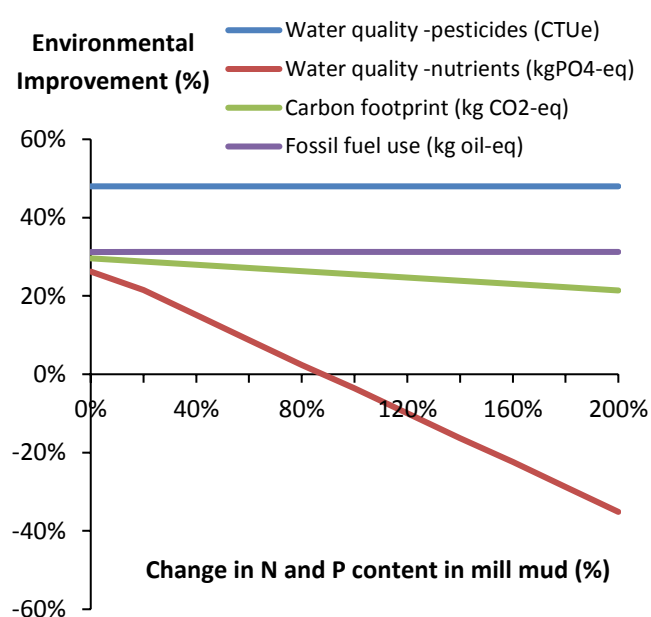


Figure 5: Environmental impact (impact/t cane) sensitivity to N and P content in mill mud (%)



The impact of Smartcane BMPs on business and the environment in the Wet Tropics

Case Study 4: Chris Bosworth

This case study is the fourth in a series that evaluates the economic and environmental impact of Smartcane Best Management Practice (BMP) adoption by a number of sugarcane growers in the Wet Tropics of north Queensland. Economic, biophysical and farm management data before and after BMP adoption was supplied by the grower and the Farm Economic Analysis Tool (FEAT)¹ and CaneLCA Eco-efficiency Calculator (CaneLCA)² were used to determine the impact of these changes on business performance and the environment. The findings of these case studies are specific to the individual businesses evaluated and are not intended to represent the impact of Smartcane adoption more broadly.

Key findings of the Chris Bosworth case study

The transition to BMP, which began in 2008, has resulted in:

- Annual improvement in farm operating return of \$78/ha (\$11,305/yr total)
- 7kg less pesticide active ingredients and 1.25 tonnes less nitrogen and phosphorous lost to waterways annually
- Annual fossil fuel use (over the life cycle of sugarcane growing) reduced by 14 per cent (or 11 tonnes of fuel)
- Greenhouse gas emissions reduced by 15 per cent annually (equivalent to taking 28 cars off the road each year).

About the farm

Chris Bosworth farms 150 hectares of sugar cane in the Herbert region, north Queensland. Chris uses a contractor for planting and harvesting and shares most of his spraying, tillage and fertilising machinery with a neighbouring farm. Chris began moving to BMP in 2008 and over the past eight years has implemented a range of best management practices on his farm. Today, Chris is a Smartcane BMP accredited grower.

What changes were made?

The main changes to Chris' farming system are summarised in Table 1.

To reduce compaction and improve soil health, Chris widened his row spacing from 1.62m to 1.8m to match the wheel tracks on his contractor's harvester. It took six years to move to 1.8m spacing on all blocks.

Chris has moved from conventional to zonal tillage and plants in preformed beds. In fallow, Chris plants cowpea.

To improve nutrient management, Chris adopted the Six-Easy-Steps guidelines. Nitrogen rates recommended by

Image 1: Chris Bosworth



¹ FEAT is a Microsoft Excel[®] based tool that models sugarcane farm production from an economic perspective, allowing users to record and analyse revenues and costs associated with their sugarcane production systems. <https://www.daf.qld.gov.au/plants/field-crops-and-pastures/sugar/farm-economic-analysis-tool>.

² CaneLCA is a Microsoft Excel[®] based tool that calculates 'eco-efficiency' indicators for sugarcane growing based on the life cycle assessment (LCA) method. It streamlines the complex LCA process to make it more accessible to researchers, agricultural advisors, policy makers and farmers. <https://eshop.uniquet.com.au/canelca/>

Six-Easy-Steps were 44kg/ha less nitrogen in plant cane and 22kg/ha less nitrogen in ratoons. Chris also adopted banded mill mud application in ratoon cane.

Chris uses a variable rate spray controller installed on his high rise sprayer which has improved the accuracy of his spray rate.

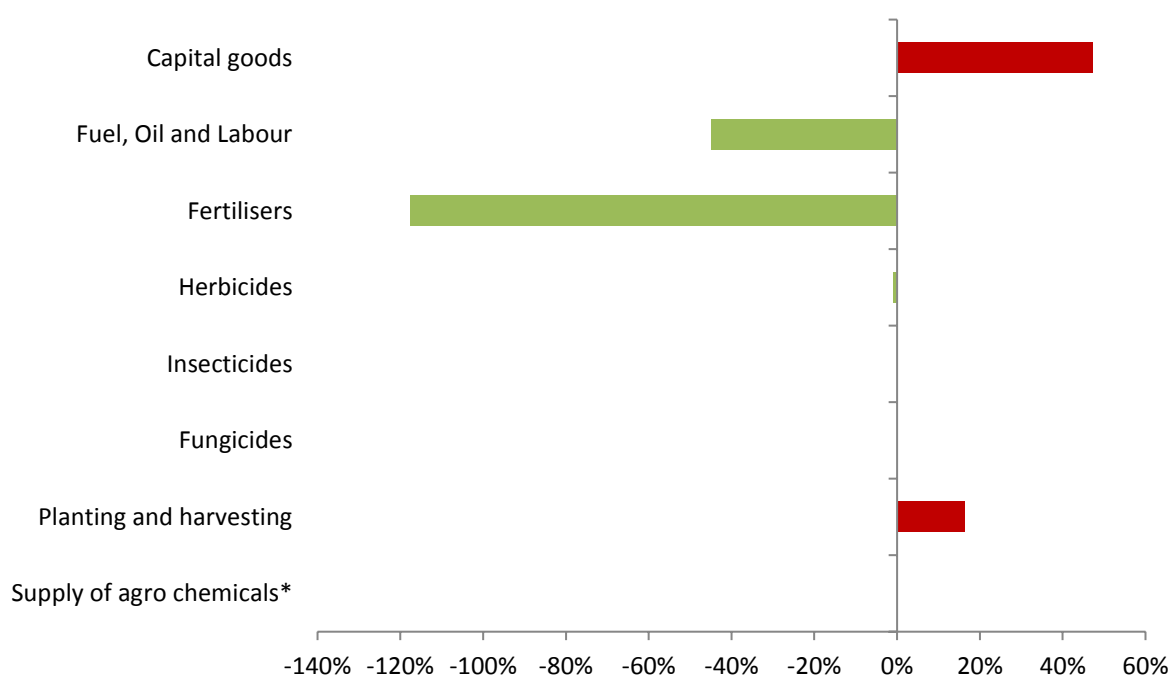
Table 1: Main changes to the new farming system

	Before	After
Weed, Pest and Disease Management	<ul style="list-style-type: none"> 2kg/ha Velpar K4 (468g/kg Diuron and 132g/kg Hexazinone) in plant cane 	<ul style="list-style-type: none"> No Diuron in plant cane Dual Gold (960g/L metolachlor) in plant cane Variable rate controller
Soil Health	<ul style="list-style-type: none"> Bare fallow 1.6m row spacing 	<ul style="list-style-type: none"> Cowpea fallow 1.8m row spacing Reduced tillage
Nutrient Management	<ul style="list-style-type: none"> Grower determined nutrient rate Broadcast mill mud application 	<ul style="list-style-type: none"> Six-Easy-Steps nutrient rate Banded mill mud application in ratoons

What does this mean for the business?

Economic analysis indicates that Chris' operating return has increased by \$78/ha/yr (\$11,305/yr total) under the new BMP farming system, due to lower operating costs. The biggest contributors to this decrease in operating costs were; fertiliser costs (-117 per cent, -\$92/ha); fuel, oil and labour (-45 per cent, -\$35/ha); which were partially offset by increases in capital goods costs (+47 per cent, +\$37/ha) and planting and harvesting (+16 per cent, +\$13/ha) (Figure 1).

Figure 1: Contribution to change in farm operating costs (%)



*Cost to supply agro-chemicals is embodied in fertilisers /herbicide /insecticide /fungicide cost.

In terms of cost savings from BMP adoption, reduction in fertiliser and mill mud use has had a significant impact. Through adoption of the Six-Easy-Steps nutrient program and banded mill mud application, Chris now spends \$92/ha less on fertiliser.

Wider row spacing, which reduces tractor hours through the reduction of the total number of rows and therefore the distance travelled, as well as zonal tillage, has contributed to additional cost savings in fuel, oil and labour of \$35/ha.

Capital goods (Figure 1) refer to the cost of repairs, maintenance and depreciation of machinery and equipment. After BMP adoption repairs and maintenance costs decreased as a result of reduced tractor hours. However, these cost savings were more than offset by an increase in depreciation costs due to new machinery and equipment purchased to implement BMP.

Increased planting and harvesting costs reflect the cost of planting a cowpea fallow.

How much did it cost to make the change?

Chris moved to BMP by investing in new machinery and machinery modifications in partnership with a neighbouring farm. To move to 1.8m row spacing and zonal tillage, Chris modified a spray rig, high rise and rotary hoe. Chris also purchased a set of ratooning discs which were converted to a bedformer, as well as a GPS and steering kit, variable rate controller, and stool splitter. The total cost of implementation was \$698/ha or \$100,475, which was Chris' half-share in the total investment³.

Was the investment profitable?

Results of an investment analysis show that BMP adoption was worthwhile for Chris when the investment was shared in with another grower. It would take eight years to repay the \$100,475 invested.

Over a ten year investment horizon, Chris' investment has added an additional \$25/ha/yr to his bottom line (when the initial investment, required return of 7 per cent and time to transition to the new system is taken into account) (Table 2).

This analysis is based on the assumption that the same rate of production is maintained after BMP adoption, which was Chris' experience.

Chris could have invested up to \$125,749 (\$873/ha) before the cost savings made by adopting BMP would be insufficient to provide the required (7 per cent) return on investment (Table 2, Investment capacity).

Table 2: Total cost change, capital investment and value of investment

Cost of Implementation (\$/ha)	\$698
Discounted Payback Period	8 years
Annual Benefit (\$/ha/yr)	\$25
Internal Rate of Return	12%
Investment Capacity (\$/ha)	\$873

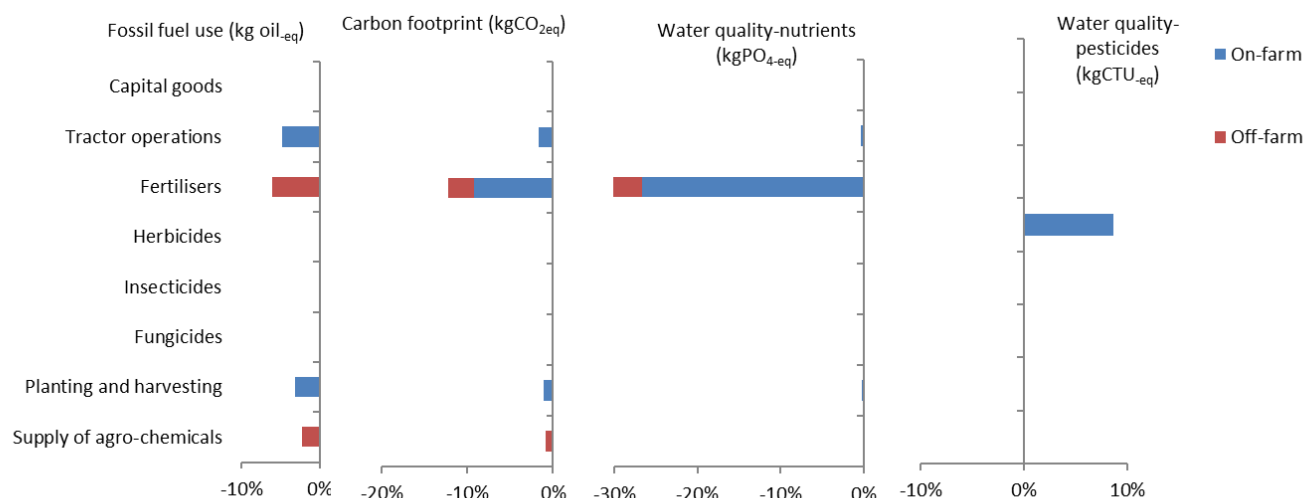
What does this mean for the environment?

The estimated change in environmental impacts for Chris' farming system before and after BMP adoption is shown in Figure 2.

After BMP adoption, annual fossil-fuel use over the life cycle of cane growing (i.e. on-farm plus off-farm) was reduced by 14 per cent overall. This means avoiding around 11 tonnes of fossil fuel use per year⁴. Half of this occurs off-farm, due to less fertiliser being produced at the factory and supplied to the farm. Avoided urea use is the biggest fossil fuel-saver because its production is energy intensive, but there are also some savings from reductions in the use of other fertiliser ingredients (DAP, KCl, Gran-am). The other half of the fossil fuel savings are due to the reductions in on-farm fuel use for tractor and harvester operations as a result of wider row spacing.

³ For the purpose of evaluating the economic costs/benefits of BMP adoption, grant funding was not considered in the economic analysis; however it is worth noting that, because of successful applications through Reef Rescue rounds 1 to 8, Chris' investment was further reduced by 50 per cent and this had a significant impact on the adoption decision.

⁴ Fossil fuel use over the whole life cycle of the farming operation includes not just on-farm diesel consumption but also off-farm use of fossil fuels in the production of fertilisers, pesticides, lime, electricity.

Figure 2: Increase / decrease in environmental impacts after adoption of BMP (per ha)⁵

The carbon footprint (greenhouse gas emissions) of cane production is reduced by 15 per cent overall after BMP adoption. This means avoiding around 87 tonnes of carbon dioxide per year across the whole farming operation, the equivalent of taking 28 cars off the road for a year. Most of the carbon footprint reductions are due to less on-farm emissions of nitrous oxide⁶ (a strong greenhouse gas) due to reductions in the amount of total nitrogen applied⁷. The rest are due to the avoidance of off-farm production and supply of fertilisers (mostly urea), and less machinery use from the wider row spacing.

The potential for water quality impacts from nutrients losses to water, via surface water runoff and groundwater infiltration, was estimated to reduce by around 30 per cent. This means the avoidance of around 1.25 t of eutrophying substances (nitrogen and phosphorus) potentially being lost to water per year. This is because less nitrogen and phosphorus are now being applied⁸.

The potential for water quality impacts from losses of pesticides to water was estimated to increase by 9 per cent. The quantities of pesticide active ingredients (AI) applied decreased slightly, resulting in about 7 kg less pesticide AI being lost to water. However a change in types of herbicide AI used meant that the overall toxicity of the releases may have increased, due to the introduction of additional metolachlor applications in plant cane. It is expected that there is some uncertainty in the assumed toxicity potentials used in this analysis⁹, and so there is not high confidence in this result. However it does flag the importance of understanding the comparative toxicity potential of AIs when changing to alternative pesticide products.

⁵ A negative value is a decrease in environmental impact, and a positive value is an increase in impacts.

kg oil_{eq} = kilograms of oil equivalent, the reference substance for measuring fossil-fuel resource depletion

kg CO_{2eq} = kilograms of carbon dioxide equivalent, the reference substance for measuring greenhouse gases

kg PO_{4eq} = kilograms of phosphate equivalent, the reference substance for measuring eutrophication of water due to releases of nutrients (N, P) and sugar

kg CTU_{eq} = kilogram of equivalent critical toxicity units, a measure of eco-toxicity in freshwater due to releases of pesticides

⁶ The assessment assumes a generic nitrous oxide (N₂O) emission factor of 1.99% of applied N lost as nitrous oxide N, which is based on the latest Australian greenhouse gas inventory methodology. The global warming potential is 298 kg CO_{2eq}/kgN₂O.

⁷ There is some uncertainty in this conclusion because the exact amount of nitrogen contained in the applied mill mud was not known. The sensitivity of our findings to this are considered in the 'What about the risk' section.

⁸ There is some uncertainty in this conclusion because the exact amount of nitrogen contained in the applied mill mud was not known. The sensitivity of our findings to this are considered in the 'What about the risk' section.

⁹ The analysis was based on assumed toxicity potentials for the applied pesticide active ingredients, which were derived from USETox model, a scientific consensus toxicity model developed by the United Nations Environment Program (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC).

What about risk?

When adopting any management practice change there is always a risk that things may not go as planned (e.g. yield loss, financial risk). The adoption of management practices that have been scientifically validated, such as BMP, means that an adverse impact on production is unlikely.

Results of a production risk analysis show that profitability is highly sensitive to maintaining yield. If overall yield were to decline by as little as 1 per cent investing in BMP adoption is unprofitable (Figure 3).

From an environmental perspective, there are two aspects that the outcomes are sensitive to, the first is cane yield, and the second is the N and P content of the mill mud.

In relation to cane yields, for there to be no net gains in environmental impacts (per tonne cane produced), yields across plant and ratoon cane would need to decline by 30 per cent for nutrient-related water quality impacts, and 20 per cent carbon footprint and fossil fuel use. For pesticide-related water quality impacts, yields would have to increase by around 10 percent for there to be no net gain (Figure 4).

The analysis was based on the assumption that the N and P content of mill mud are 0.075% and 0.065% wt./wt. respectively; however the exact N and P content of mill mud was not known and can vary considerably. Results of a sensitivity analysis show that the assumed N and P contents of the mill mud would have to double for there to be no improvement in water quality (Figure 5).

Figure 3: Annual benefit of investment (\$/ha/yr) sensitivity to yield

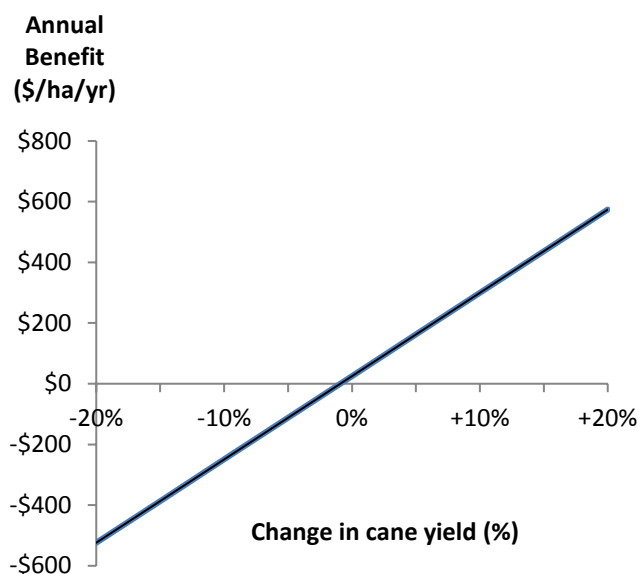


Figure 4: Environmental impact sensitivity to yield

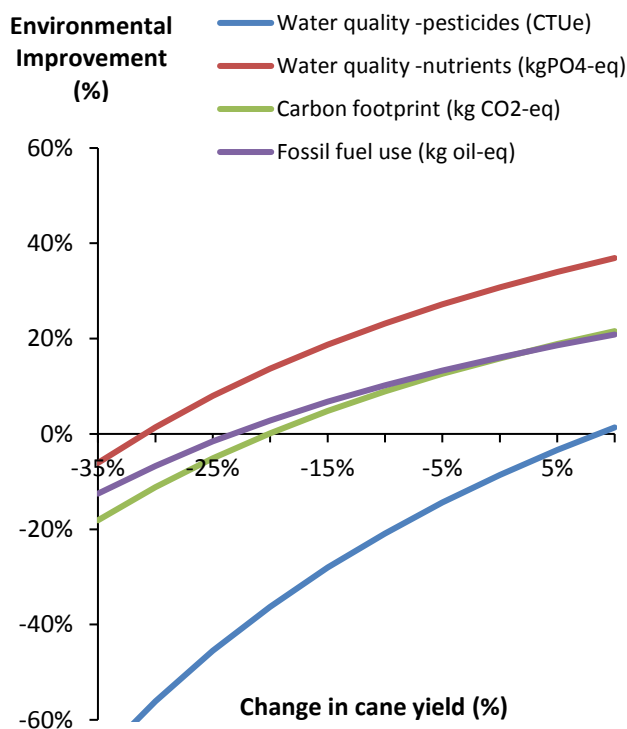
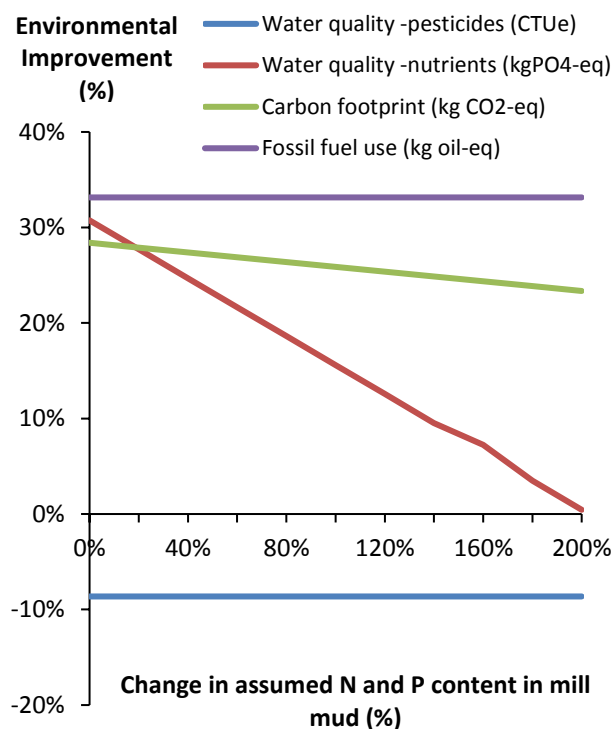


Figure 5: Environmental impact (impact/t cane) sensitivity to N and P content of mill



What's the bottom line?

This case study has evaluated the business and environmental impact of Smartcane BMP adoption for a farm in the Wet Tropics.

Results of the economic analysis indicate that BMP adoption has been a profitable investment. Cost savings were made by reducing the amount spent on fertiliser, fuel, oil, and labour, partially offset by an increase in the cost of depreciation. Chris made a substantial investment in new machinery and machinery modifications to move to BMP. By sharing this investment with another grower, Chris has reduced his investment cost and improved his return on investment. Although not included in this analysis Chris received Reef Rescue grant funding which was a key factor in Chris' decision to move to BMP.

“Without access to Reef Rescue grants it is highly likely these changes would not have been contemplated. For farmers to stay viable in the future, sharing equipment is vital. Also by teaming up with neighbours grants are easier to obtain because larger landholdings give better value for matching government funding” – Chris Bosworth

Transition to BMP has resulted in less fertiliser application and a significant reduction in the potential for water quality impacts from losses of nutrients. There has also been the added bonus of reduced fossil fuel use and greenhouse gas emissions due to less fertiliser production and use, and less machinery use. While the quantities of pesticide active ingredients applied decreased slightly, a change in the type of herbicides used meant that the overall toxicity of the releases may have increased slightly.

Each farming business is unique in its circumstances and therefore the parameters and assumptions used in this case study reflect Chris' situation only. Consideration of individual circumstances must be made before applying this case study to another situation.

This case study forms a component of SRA Project 2014/15 (Measuring the profitability and environmental implications when growers transition to Best Management Practices). For further information contact the Townsville DAF office on (07) 3330 4560

The impact of Smartcane BMPs on business and the environment in the Wet Tropics

Case Study 5: Walter Giordani

This case study is the fifth in a series that evaluates the economic and environmental impact of Best Management Practice (BMP, as defined by Smartcane BMP) adoption on sugarcane farms in North Queensland. Information from before and after BMP adoption was supplied by the farmer and the Farm Economic Analysis Tool (FEAT)¹ and CaneLCA Eco-efficiency Calculator (CaneLCA)² were used to determine the impact of these changes on business performance and the environment. The findings of these case studies are specific to the individual businesses evaluated and are not intended to represent the impact of BMP adoption more broadly.

Key findings of the Walter Giordani case study

The transition to BMP, which began in 2010, has resulted in:

- Progressive improvement in production compared to the productivity zone (18 tch or 27%).
- Annual improvement in farm operating return of \$429/ha (\$37,834/yr total).
- 46kg less pesticide active ingredients and 250kg less eutrophying substances (nitrogen and phosphorous) potentially being lost to waterways annually.
- Fossil fuel use reduced by 18 per cent per tonne of cane over the life cycle (0.2 t/yr of oil).
- Annual greenhouse gas emissions reduced by 20 per cent per tonne of cane.

“The focus of my investments have centred on maximising my yield improvement and becoming sustainable into the future of the industry”

About the farm

Walter Giordani farms 90 hectares of sugarcane in the Herbert region and recently attained Smartcane BMP accreditation. Walter purchased his home farm in 2009 and another farm in 2013. He set about identifying areas that might lift production. Firstly, he identified waterlogging issues and laser levelled the farm to improve drainage. Soon after making the change, Walter observed yield improvements from his initial investment so he looked for additional areas of improvement. He attended local productivity services meetings and was introduced to new farming practices such as soil testing to identify the nutrient and ameliorant (lime) requirements of his soils. Walter observed further yield improvements and that success spurred him on to adopt other sustainable practices including legume fallow cropping, wider row spacing, GPS guidance, minimum tillage and eventually mound planting. All of Walter’s investments took a step-by-step approach with the aim to improve yield potential.

Image 1: Walter Giordani near a ratoon crop



¹ FEAT is a Microsoft Excel® based tool that models sugarcane farm production from an economic perspective, allowing users to record and analyse revenues and costs associated with their sugarcane production systems. <https://www.daf.qld.gov.au/plants/field-crops-and-pastures/sugar/farm-economic-analysis-tool>

² CaneLCA is a Microsoft Excel® based tool that calculates ‘eco-efficiency’ indicators for sugarcane growing based on the life cycle assessment (LCA) method. It streamlines the complex LCA process to make it more accessible to researchers, agricultural advisors, policy makers and farmers. <https://eshop.uniquet.com.au/canelca/>

Since implementing the improved management practices over the past eight years, production has improved considerably on Walter's home farm relative to the productivity zone average. Figure 1 compares the average cane yield on Walter's home farm to the productivity zone average and shows the progressive improvement in yield since making the farming system changes. In the first few years of farm operations, he was around the productivity zone average. However, over the past 5 years (2012-16) Walter's cane yields have on average been 18 tonnes of cane per hectare (tch) above the productivity zone, which is a 27% improvement.

Figure 1: Comparison of cane yield on home farm to the productivity zone.



What changes were made?

The main changes to Walter's farming system are summarised in Table 1. Walter now laser levels to improve drainage and grows a legume crop in his fallow for green manure. He has also reduced his tillage operations³ and started planting into preformed beds. In addition, he uses GPS guidance and has widened his row spacing from 1.52m to 1.62m. To improve nutrient management, Walter uses the Six-Easy-Steps guidelines to determine the type and quantity of nutrients and soil ameliorants required. For weed management, he now sprays with a hi-rise tractor, band sprays chemicals using shields and has changed some of the types of herbicides that he applies.

Table 1: Main changes to the new farming system

	Before	After
Drainage	<ul style="list-style-type: none"> Minimal drainage work 	<ul style="list-style-type: none"> Laser levelling to improve drainage
Soil health	<ul style="list-style-type: none"> Bare fallow Heavy tillage 	<ul style="list-style-type: none"> Legume fallow crop (Cowpeas) Reduced tillage and planting into preformed beds GPS guidance Widened row spacing (1.52 to 1.62m)
Nutrient management	<ul style="list-style-type: none"> Grower determined nutrient rates 	<ul style="list-style-type: none"> Using Six Easy Steps to determine required nutrients and soil ameliorants (lime)
Weed, pest and disease	<ul style="list-style-type: none"> Spraying rows and inter-rows with the same chemicals. 	<ul style="list-style-type: none"> Band spraying chemicals using shields Spraying with hi-rise tractor Changed some types of herbicides

³ He now discs less and has stopped ripping, rotary hoeing, centre busting, grubbing and weed raking.

How much did it cost to make the change?

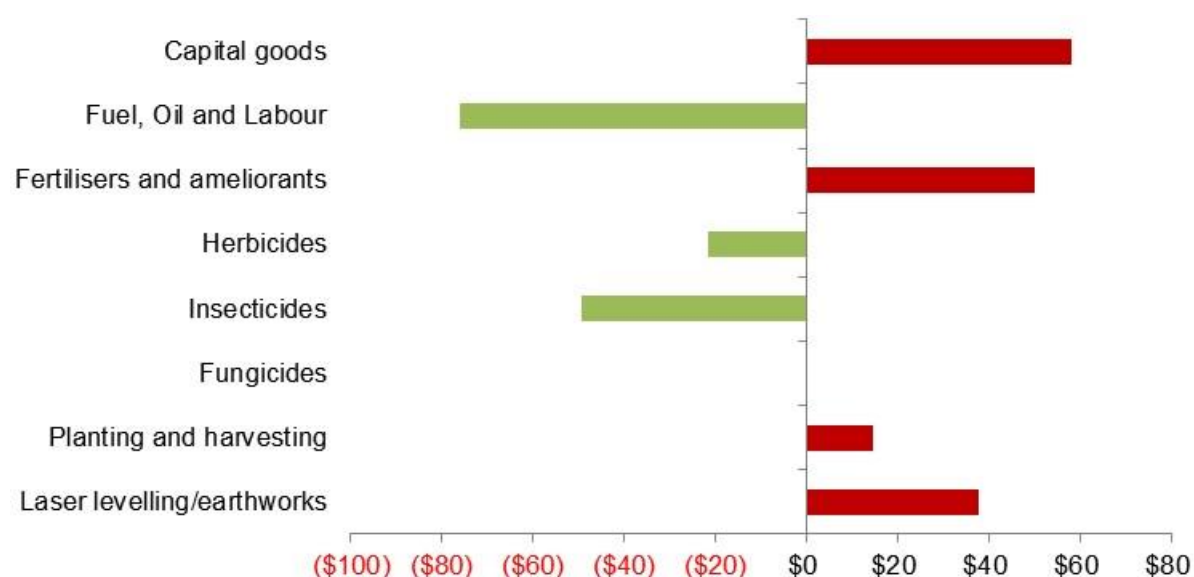
Modifications of existing machinery was carried out to match wheel spaces to the wider rows (\$6000). There was also a need to invest in new equipment including GPS guidance (\$32,000), a stool splitter (\$32,000), a bed renovator (\$25,000) and a legume planter (\$6,500). Also, one tractor was raised to enable hi-rise spraying and new spray tanks and shielded sprayers were purchased⁴ (\$50,000). The total cost of implementation was \$151,500 (or \$1,718/ha).

What does this mean for the business?

An economic analysis of Walter's transition to a Best Management Practice farming system indicates his operating return increased by \$429/ha/yr (\$37,834/yr total). This is a direct result of differences in operating costs between the conventional and improved farming system and an improvement in cane yields (27%). The main differences in operating costs are illustrated in Figure 2 and include:

- **Capital goods**⁵ – machinery repair and maintenance costs decreased by \$51/ha due to less mileage (wider row spacing) and less tillage but were outweighed by higher depreciation costs of \$109/ha from new machinery and equipment purchases to implement BMP changes.
- **Fuel, oil and labour** – these costs decreased by \$76/ha due to less tillage and wider row spacing, which reduced tractor hours (fewer cane rows equals a shorter travelling distance).
- **Fertilisers and ameliorants** – the use of Six Easy Steps reduced the quantity of nitrogen applied and identified the need for micronutrients and other soil amelioration products. The additional lime spreading costs (\$59/ha) outweighed fertiliser cost savings of \$9/ha.
- **Herbicides** – band spraying and reduced herbicide use has lowered costs by \$21/ha.
- **Insecticides** – a switch was made from a more expensive grub control option to a cheaper product which lowered pest control costs by \$49/ha.
- **Planting and harvesting** – planting cowpeas required additional costs of \$15/ha.
- **Laser levelling** – laser levelling fallow blocks to improve drainage added costs of \$38/ha.

Figure 2: Contribution to change in farm operating costs (\$/ha)



⁴ For the purpose of evaluating the economic costs/benefits of BMP adoption, grant funding was not considered in the economic analysis; however it is worth noting that, because of successful applications through Reef Rescue, some of the investments were partially funded.

⁵ Capital goods refer to the cost of repairs, maintenance and depreciation of machinery and equipment.

Was the investment profitable?

Table 2 shows the results of an investment analysis based on a six year transitioning period to implement the changes. Given the additional revenue from increased production and lower costs, it would take six years to recover the \$151,500 (or \$1,718/ha) invested. Over a ten year investment horizon, the investment has added an additional \$19,402 per year (\$220/ha/yr) to the bottom line (when the initial investment is taken into account). This analysis is based on a 27% yield improvement after BMP adoption.

Table 2: Total cost change, capital investment and value of investment

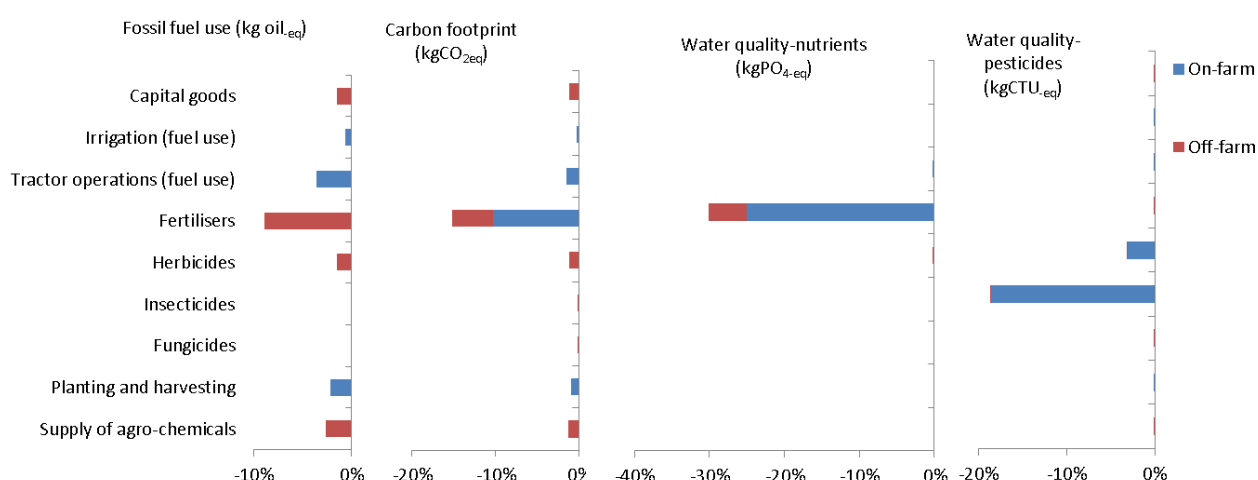
Cost of Implementation (\$/ha)	\$1,718
Discounted Payback Period	6 years
Annual Benefit (\$/ha/yr)	\$220
Internal Rate of Return	20%
Investment Capacity (\$/ha)	\$3,262

Investment capacity is the maximum amount of money that can be spent before an investment becomes unprofitable. Walter could have invested up to \$287,770 (\$3,262/ha) before the additional yield and cost savings would be insufficient to provide the required (7 per cent) return on investment.

What does this mean for the environment?

The estimated change in environmental impacts for Walter's farming system before and after BMP adoption is shown in Figure 3. After adoption, annual fossil-fuel use, over the life cycle of cane growing (i.e. on-farm plus off-farm), reduced by 18 per cent per tonne of cane overall. On-farm fuel use for tractor operations and harvesting reduced as a result of wider row spacing and less tillage. There were also off-farm reductions in energy use, due to a lower quantity of fertilisers and a slightly reduced quantity of herbicides being produced at the factory and supplied to the farm. However fuel use for harvesting was estimated to increase because the higher cane yield means a bigger crop is harvested. There was also some additional fuel use for the introduced legume crop. So, overall the total fossil-fuel use decreased marginally by around 0.2 tonnes of oil equivalent per year⁶. However increased cane yield meant fossil-fuel use efficiency per tonne of cane improved substantially (18%).

Figure 3: Increase / decrease in environmental impacts after BMP adoption (per tonne cane)⁷



The carbon footprint, which is the greenhouse gas (GHG) emissions of cane production, was reduced by around 20 per cent per tonne of cane overall after BMP adoption. The reasons for the reductions in

⁶ Fossil fuel use over the whole life cycle of the farming operation includes not just on-farm diesel consumption but also off-farm use of fossil fuels in the production of fertilisers, pesticides, lime, electricity.

⁷ A negative value is a decrease in environmental impact, and a positive value is an increase in impacts.

kg oil-eq = kilograms of oil equivalent, the reference substance for measuring fossil-fuel resource depletion

kg CO₂-eq = kilograms of carbon dioxide equivalent, the reference substance for measuring greenhouse gases

kg PO₄-eq = kilograms of phosphate equivalent, the reference substance for measuring eutrophication of water due to releases of nutrients (N, P) and sugar

kg CTU-eq = kilogram of equivalent critical toxicity units, a measure of eco-toxicity in freshwater due to releases of pesticides.

GHG emissions are the same as for fossil fuel use, because most GHG emissions are linked to fossil-fuel use. However there was also a reduction in on-farm emissions of nitrous oxide⁸ (N₂O, a strong GHG), because the introduced legume fallow meant some synthetic N fertiliser was displaced, and N₂O emissions from legume-N were assumed lower than those from synthetic-N. For the farm as a whole, there would be a reduction of around 1 tonne of carbon dioxide equivalent emitted per year over the life cycle of the farming operation, the equivalent of taking 1 car off the road for half a year. However the increased yield meant a substantial improvement in carbon efficiency per tonne of cane.

A reduction in the amount of nitrogen and phosphorous applied to the production system (reduced by 31% per tonne of cane) means there is a potential for less of these nutrients to be lost through runoff and leaching. This could mean a reduction in approximately 250 kg of eutrophying substances per year being lost from the soil through the movement of water.

The potential for water quality impacts from losses of pesticides entering waterways was estimated to decrease by about 22 per cent per tonne of cane. The quantities of pesticide active ingredients (AI) applied decreased, resulting in about 46 kg less pesticide AI being lost through water pathways per year. However a change in types of herbicide AI used (introduction of metolachlor, hexazinone and haloxyfop) meant that overall toxicity of the releases may not have changed. It is expected that there is some uncertainty in the assumed toxicity potentials used in this analysis⁹, and so there is not high confidence in this result. However it does flag the importance of understanding the comparative toxicity potential of AIs when changing to alternative pesticides. Despite no net change in the overall toxicity potential of the AI lost from the farm, because the cane yields increased the impact per tonne of cane is lower (22%).

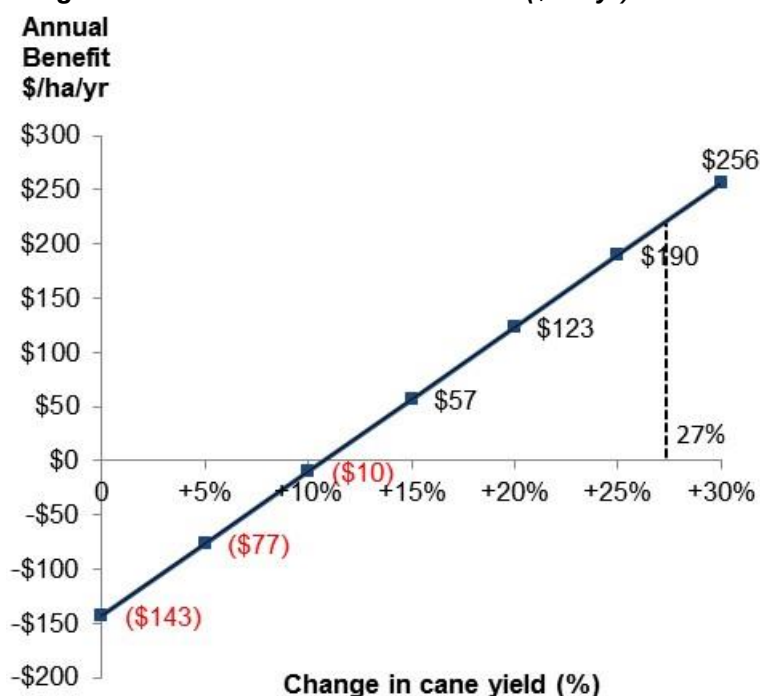
What about risk?

A key factor driving Walter's investment was improvements in yield. While the previous analysis examined a 27% yield improvement, this section examines the influence on profitability and the environment given different cane yield improvements.

Figure 4 shows the results of a yield sensitivity analysis, which indicates that the annual benefit is sensitive to the yield improvement. The average farm yield would need to improve by 11 per cent (or 7 tch) or greater to make the investment profitable, which is 16% less than the 27% yield improvement examined.

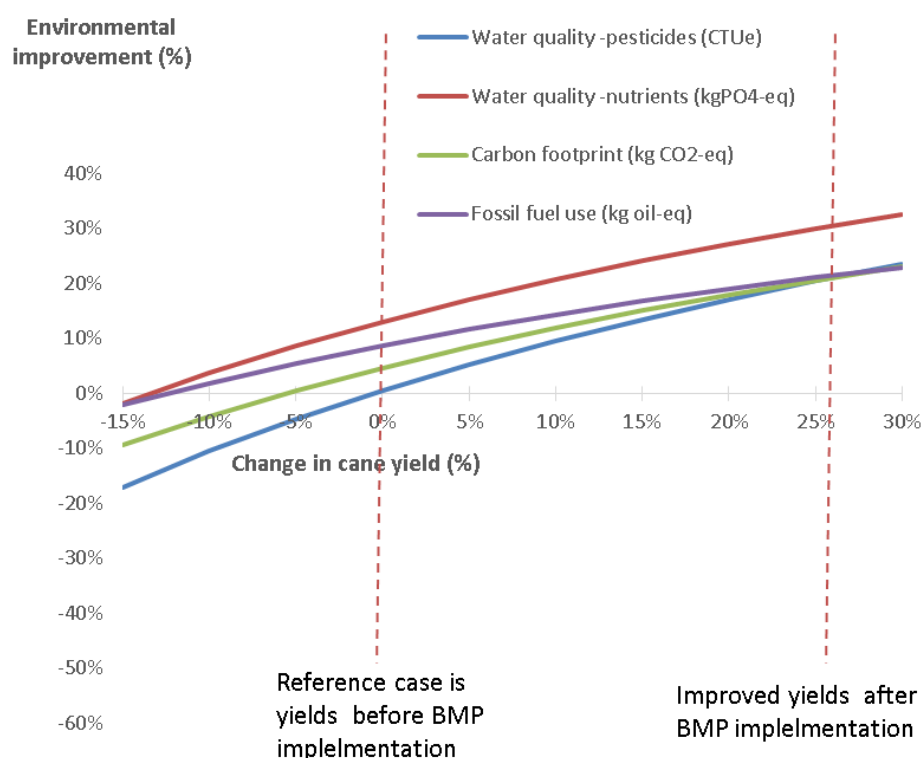
From an environmental perspective, the environmental improvements are sensitive to cane yield (Figure 5). If the cane yields after implementation had remained the same as before, there would have been environmental improvements in the order of 5-10% (per tonne of cane) for all impact categories except pesticide-related water quality impacts, which would have remained about the same. However because yields increased after implementation (by 27%), the scale of those environmental improvements per tonne of cane were greater (20-30%).

Figure 4: Annual benefit of investment (\$/ha/yr)



⁸ The assessment assumes a generic nitrous oxide (N₂O) emission factor of 1.99% of applied N lost as nitrous oxide N, which is based on the latest Australian greenhouse gas inventory methodology. The global warming potential is 298 kg CO_{2-e}/kg N₂O.

⁹ The analysis was based on assumed toxicity potentials for the applied pesticide active ingredients, which were derived from USETox model, a scientific consensus toxicity model developed by the United Nations Environment Program (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC).

Figure 5: Environmental impact sensitivity to yield

What's the bottom line?

This case study evaluated the business and environmental impact of BMP adoption for a Wet Tropics farm. Since 2010, Walter has progressively adopted BMPs to improve yield potential on his farm. Changes included improving drainage, using the Six Easy Steps, growing a legume crop, reducing tillage and widening row spacing. Walter has observed progressive improvements in production since implementing new practices and believes it is critical to continually improve his farming operation.

The results from the economic analysis indicate cost savings from lower fuel and chemical use, reduced labour requirements and less repairs and maintenance. These coincided with some additional costs from laser levelling, applying lime as a soil ameliorant and planting legumes as well as higher depreciation costs from new machinery purchases. Overall, the investment analysis shows an improvement in farm profitability and that the investment in new machinery and equipment has proved to be a worthwhile investment. The risk analysis reveals that a yield improvement of 11% would have made the investment profitable, which is 16% less than the 27% improvement examined.

Transition to BMP has resulted in less fertiliser application and a reduction in the potential for water quality impacts from nutrient loss. While the quantities of pesticide active ingredients applied decreased slightly, a change in the type of herbicides used meant that the toxicity of the releases did not decrease overall. There has also been the added bonus of reduced fossil fuel use and greenhouse gas emissions due to less fertiliser production and use, and less machinery use. The estimated reductions in impact overall per tonne of cane can partly be attributed to increased yields.

Each farming business is unique in its circumstances and therefore the parameters and assumptions used in this case study reflect Walter's situation only. Consideration of individual circumstances must be made before applying this case study to another situation.

This case study forms a component of SRA Project 2014/15 (Measuring the profitability and environmental implications when growers transition to Best Management Practices). For further information contact the Townsville DAF office on (07) 3330 4560.

The impact of BMPs on business and the environment in the Wet Tropics

Case Study 6: David Singh

This case study is the sixth in a series that evaluates the economic and environmental impact of Best Management Practice (BMP) adoption by a number of sugarcane growers in the Wet Tropics of North Queensland. Economic, biophysical and farm management data before and after BMP adoption were supplied by the grower. The Farm Economic Analysis Tool (FEAT)¹ and CaneLCA Eco-efficiency Calculator (CaneLCA)² were used to determine the impact of the BMP changes on business performance and the environment. The findings of these case studies are specific to the individual businesses evaluated and are not intended to represent the impact of BMP adoption more broadly.³

Key findings of the David Singh case study

The transition to BMP, which began prior to 2000, has resulted in:

- An annual improvement in farm operating return of \$107/ha/yr (\$81,244 total)
- 370 kg less pesticide active ingredients (52 per cent decrease) and 434 kg less eutrophying substances (nitrogen and phosphorous) potentially being lost to waterways annually.
- Annual fossil fuel use reduced by 10 per cent (or 35 tonnes of oil over the cane life cycle)
- Greenhouse gas emissions reduced by 7 per cent annually (equivalent to taking 56 cars off the road each year).

About the farm

David Singh farms 760 hectares of sugar cane in Carruchan (Kennedy), North Queensland. David does his own planting and uses contractors for harvesting. He grows a legume fallow on half of his fallow area in rotation with sugarcane. David has implemented a range of best management practices on his farm to improve profitability and reduce his environmental impact.

Image 1: David Singh



What changes were made?

The main changes to David's farming system are summarised in Table 1. To reduce compaction and improve soil health, David widened his row spacing from 1.58m to 1.8m (this is close to the 1.83m wheel tracks on his contractor's harvester) and fitted five tractors with GPS guidance. David has moved from conventional to zonal ripping in preformed beds and has halved the area of land rotary hoed. To improve nutrient management, David

¹ FEAT is a Microsoft Excel[®] based tool that models sugarcane farm production from an economic perspective, allowing users to record and analyse revenues and costs associated with their sugarcane production systems. <https://www.daf.qld.gov.au/plants/field-crops-and-pastures/sugar/farm-economic-analysis-tool>.

² CaneLCA is a Microsoft Excel[®] based tool that calculates 'eco-efficiency' indicators for sugarcane growing based on the life cycle assessment (LCA) method. It streamlines the complex LCA process to make it more accessible to researchers, agricultural advisors, policy makers and farmers. <https://eshop.uniquet.com.au/canelca/>

³ Various management practice changes have been made progressively by David since 2000 and prior to 2000 (well before the Smartcane BMP program was initiated). Given the progressive nature of the changes and limited accessibility of data in some instances, certain aspects of this case study have been simplified and modelled over a 10 year period (base year: 2007).

varies fertiliser rates and lime rates between blocks.⁴ His applied fertiliser rates have decreased since following Six Easy Steps guidelines. Additional changes made by David include reducing the use of some chemicals whilst maintaining weed control and using a variable rate spray controller (which has improved the accuracy and efficiency of his spray rate). David has improved drainage by laser levelling, undertaking earthworks, and installing underground pipes and spoon drains.

David is an early adopter of new sugar cane varieties and is an active participant in the Tully Sugar Limited led New Variety management program which aims to promote BMP in variety adoption and management.

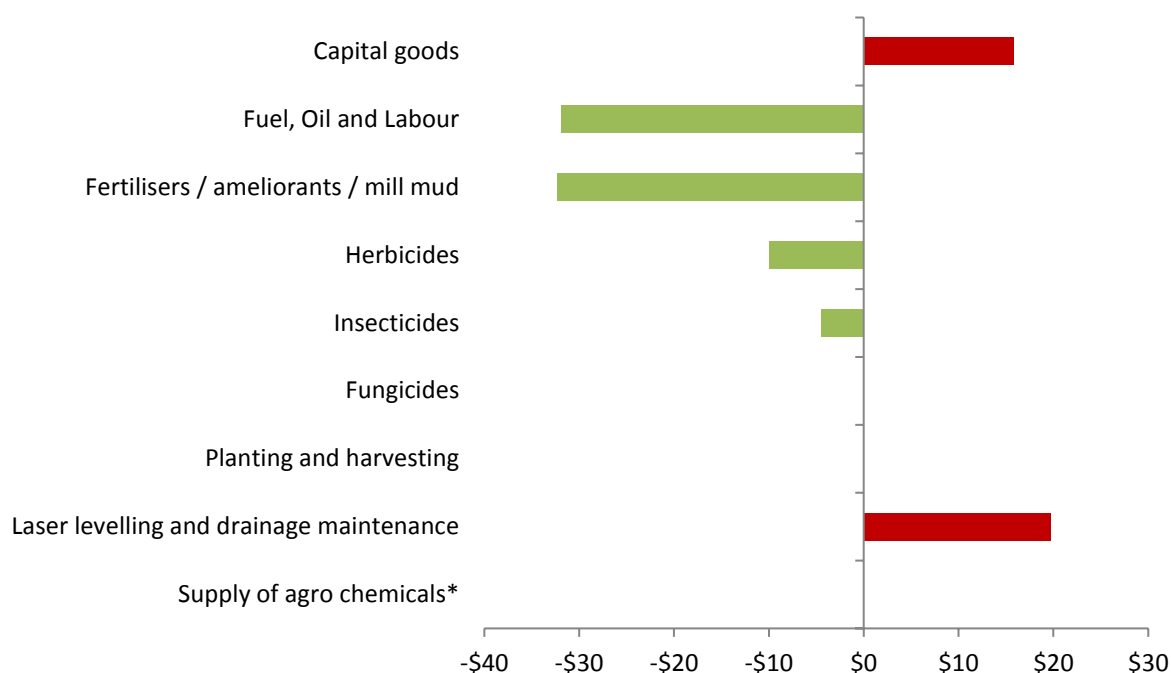
Table 1: Main changes to the new farming system

	Before	After
Soil Health	<ul style="list-style-type: none"> • 1.58m row spacing • No GPS guidance for machinery operations • Conventional planting • Heavy tillage / machinery operations (discing, ripping, strategic rotary hoe 20% of blocks, grubbing, marking out) 	<ul style="list-style-type: none"> • 1.8m row spacing • GPS guidance for machinery operations (auto steer ensures controlled traffic on 1.8m rows) • Bed forming and conventional planting • Reduced tillage/machinery operations (reduced discing, zonal ripping, strategic rotary hoe 10% of blocks, bed forming)
Nutrient Management	<ul style="list-style-type: none"> • Grower determined nutrient rate • Applying same fertiliser rate across all blocks • Applying same lime rate in all (fallow) blocks 	<ul style="list-style-type: none"> • Following Six Easy Steps guidelines to reduce inorganic fertiliser rates • Varying fertiliser rate between blocks • Varying lime rate between (fallow) blocks
Weed, Pest and Disease Management	<ul style="list-style-type: none"> • Standard spraying/calibration 	<ul style="list-style-type: none"> • Variable rate spray controller • Reduced use of some chemicals in plant cane and ratoons.
Drainage	<ul style="list-style-type: none"> • Drainage issues (waterlogging, machinery ruts and bogging) 	<ul style="list-style-type: none"> • Improved drainage (by laser levelling, undertaking earthworks, installing underground pipes and spoon drains)

What does this mean for the business?

Economic analysis indicates that David's operating return has increased by \$107/ha/yr (\$81,244 total) after making a number of BMP changes. This is the result of lower operating costs after BMP adoption. The biggest contributors to the change in operating costs included: fertiliser and ameliorant costs (-\$32/ha); fuel, oil and labour costs (-\$32/ha); capital goods costs (+\$16/ha); herbicides (-\$10/ha); and insecticides (-\$5/ha) (Figure 1).

⁴ Rates depend on soil tests and are varied between (not "within") blocks.

Figure 1: Contribution to change in farm operating costs (\$/ha)

* Cost to supply agro-chemicals is embodied in fertilisers /herbicide /insecticide /fungicide cost.

After varying his lime (ameliorant) rate between blocks, David now applies lime to 10% less area and his application rate has been reduced by 0.5t/ha. A reduction in fertiliser application rates in David's plant cane has resulted in further cost savings. David has continued using a legume crop for half of his fallow area, but after adoption of Six Easy Steps guidelines, has now adjusted his nutrient application rates to account for nitrogen from the legume crop.

Reduced tillage has made a large contribution to cost savings (reducing fuel, oil and labour costs). Wider row spacing, which reduces tractor hours through the reduction of the total number of rows and therefore distance travelled, has also contributed to cost savings. In David's experience, GPS guidance also reduces tractor hours.

Capital goods (Figure 1) refer to the cost of repairs, maintenance and depreciation of machinery and equipment. After BMP adoption, repairs and maintenance costs decreased as a result of reduced tractor hours. However, depreciation increased due to new equipment purchased. David has also incurred an increase in costs related to maintaining drainage and occasionally laser levelling (\$20/ha).

How much did it cost to make the changes?

To move to a controlled traffic reduced tillage system with 1.8m single row spacing, David purchased five GPS units, modified the wheel spacing on his machinery, purchased a zonal ripper and purchased a bed former. A variable rate spray controller was purchased and fitted onto the existing spray equipment. Also, he has progressively laser levelled his farm and completed earthworks to improve drainage.

The total cost of implementation was \$735,016 (or \$967/ha). The costs for laser levelling and earthworks occurred progressively in each fallow block until full implementation.

Was the investment profitable?

Results of an investment analysis show that BMP adoption was a worthwhile investment. It would take 10 years to repay the \$735,016 invested.⁵

Over a ten year investment horizon, David's investment has added an additional \$57/ha/yr to the bottom line (when the initial investment, required return of 7 per cent and time to transition to the new system is taken into account) (Table 2).

This analysis is based on the assumption that yield is maintained after BMP adoption. In David's experience, yields have improved after making the BMP changes. He is of the view that, in particular, the improved drainage on his farm has helped reduce waterlogging and, together with controlled traffic changes, has improved yields.⁶

David could have invested up to \$1,041,142 (\$1,370/ha), or \$306,126 (\$403/ha) more than his actual investment, before the cost savings made by adopting various BMPs would be insufficient to provide the required (7 per cent) return on investment.

Table 2: Total cost change, capital investment and value of investment

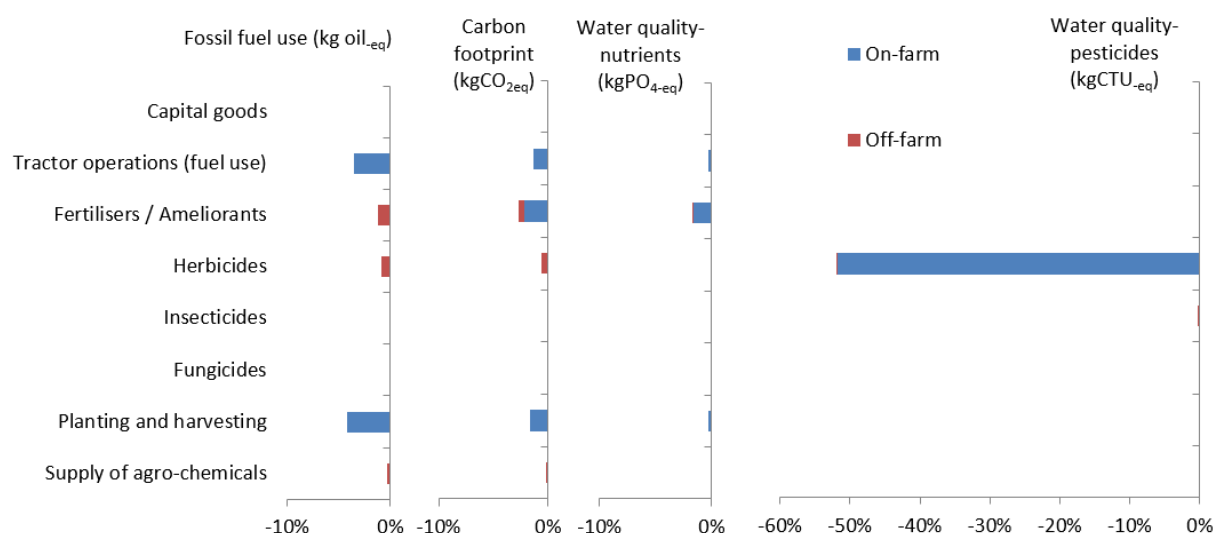
Cost of Implementation (\$/ha)	\$967
Discounted Payback Period	10 years
Annual Benefit (\$/ha/yr)	\$57
Internal Rate of Return	13.7%
Investment Capacity (\$/ha)	\$1,370

What does this mean for the environment?

The estimated change in environmental impacts for David's farming system before and after BMP adoption is shown in Figure 2.

After BMP adoption, annual fossil-fuel use over the life cycle of cane growing (i.e. on-farm plus off-farm) was reduced by 10 per cent overall. This means avoiding around 35 tonnes of oil equivalent per

Figure 2: Increase / decrease in environmental impacts after BMP changes (per ha)



⁵David expects that if he were to sell his farm, costs of initial laser levelling and drainage earthworks implemented over a 10 year period would be recovered in improved farm value and, therefore, these changes are treated in the analysis as capital improvements.

⁶ It is emphasised that this is the personal view of David Singh only. The findings of these case studies are specific to the individual businesses evaluated and are not intended to represent the impact of BMP adoption more broadly. As noted previously, various aspects of this case study have been simplified and modelled. For example, David considers that some machinery upgrades (excluded from this analysis) have also assisted him in applying herbicides during certain "windows of opportunity" when the weather is appropriate and have, in turn, improved yields. Whilst David now grows up to six ratoons on his farm, only four ratoons are modelled to be conservative. It is noted that, whilst extended ratoons (that maintain high yields) may improve profitability, a detailed consideration of any such yield improvements is beyond the scope of this analysis.

year.⁷ On-farm fuel use for tractor operations and harvesting was reduced as a result of wider row spacing and reduced tillage. There were also some off-farm reductions in energy use, due to less fertilisers and pesticides being produced at the factory and supplied to the farm.

The carbon footprint, which is the greenhouse gas (GHG) emissions of cane production, was reduced by around 7 per cent overall after BMP adoption. This means that around 174 tonnes of carbon dioxide per year are now avoided over the life cycle of the farming operation, the equivalent of taking 56 cars off the road each year. The sources of reductions in GHG emissions are similar to those described for fossil fuel use. There was also a reduction, however, in on-farm emissions of nitrous oxide⁸ (N₂O, a strong GHG), due to the reduction in N fertiliser application rates.

The potential for water quality impacts from nutrients losses to water, via surface water runoff and groundwater infiltration, was estimated to reduce by around 2 per cent. This means the avoidance of around 435 kg of eutrophying substances (nitrogen and phosphorus) potentially being lost to water per year. This is again because less nitrogen is now being applied.

The potential for water quality impacts from losses of pesticides to water was estimated to decrease by about 52 per cent, and is the most significant environmental improvement. The quantities of pesticide active ingredients (AI) applied decreased, resulting in about 370 kg less pesticide AI being lost to water per year. The reduction in toxicity was also due to changes in the types of herbicide AI used, particularly the avoided use of Pendimethalin, and reduced use of Diuron, Hexazinone and Paraquat.

What about risk?

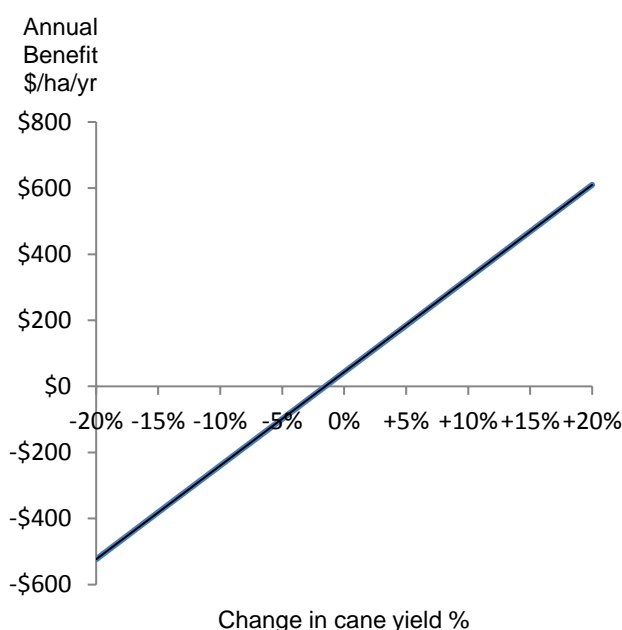
When adopting any management practice change there is always a risk that things may not go as planned (e.g. yield loss, financial risk). The adoption of management practices that have been scientifically validated, such as BMP, means that an adverse impact on production is unlikely.

Results of a production risk analysis show that yield across plant and ratoon cane would need to decline by 2% per cent before investing in BMP adoption is unprofitable (Figure 3). Conversely, a small improvement in cane yield would result in substantial economic benefits.

From an environmental perspective, the environmental improvements can also be quite sensitive to cane yield. For there to be no net reduction in environmental impacts (per tonne cane produced), yields across plant and ratoon cane would need to decline by only 2 per cent for nutrient-related water quality impacts, 15 per cent for fossil fuel use and 7 per cent for carbon footprint.

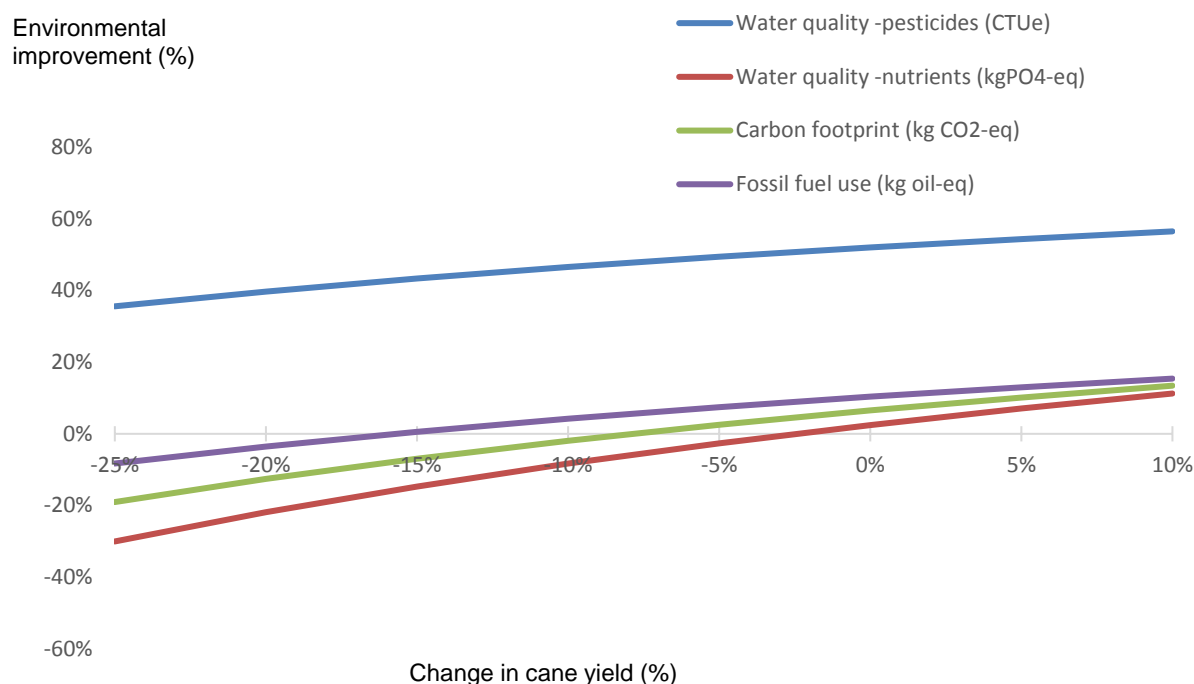
Because the improvements in pesticide-related water quality impacts are so high, there is no risk of them being compromised by yield changes (Figure 4).

Figure 3: Annual benefit of investment (\$/ha/yr) sensitivity to yield



⁷ Fossil fuel use over the whole life cycle of the farming operation includes not just on-farm diesel consumption but also off-farm use of fossil fuels in the production of fertilisers, pesticides, lime, electricity.

⁸ The assessment assumes a generic nitrous oxide (N₂O) emission factor of 1.99% of applied N lost as nitrous oxide N, which is based on the latest Australian greenhouse gas inventory methodology. The global warming potential is 298 kg CO₂-e/kg N₂O.

Figure 4: Environmental impact sensitivity to yield

What's the bottom line?

This case study has evaluated the business and environmental impact of various BMP changes for a farm in the Wet Tropics.

Results of the economic analysis indicate that the changes have resulted in cost savings for David, largely as a result of reduced fuel, oil and labour costs, and reduced fertiliser and ameliorant costs. The amount David now spends on herbicides and insecticides has also reduced. David has made a substantial investment in new technology and improved drainage and this has shown to be a worthwhile investment. David has also observed benefits in his farm production since making the changes on his farm.

“Before improving drainage and shifting to controlled traffic I had issues with machinery ruts and bogging and often couldn’t get machinery operations done on time. Now, I get better yields and extra ratoons due to being able to do operations on time when they are needed and having better soil health from reduced compaction” – David Singh

The BMP changes have resulted in reductions in the risk of water quality impacts, especially in relation to reduced toxicity due to reduced herbicide application. The reduced risk of eutrophication due to reduced N application is less. There has also been the added bonus of reduced fossil fuel use and greenhouse gas emissions due to less fertiliser production and use, and less machinery use.

Each farming business is unique in its circumstances and therefore the parameters and assumptions used in this case study reflect David Singh’s situation only. Consideration of individual circumstances must be made before applying this case study to another situation.

This case study forms a component of SRA Project 2014/15 (Measuring the profitability and environmental implications when growers transition to Best Management Practices). For further information contact the Townsville DAF office on (07) 3330 4560