Economic and Environmental Analysis of Converting to Controlled Traffic Farming

Based on a report prepared for the Clifton Allora Top Crop (CATC) Group

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BACKGROUND

The CATC Group is comprised of 16 separate farming businesses on the Eastern Darling Downs of Queensland that range in size from 260 ha to 1600 ha. The majority of these properties have been continuously farmed for in excess of 100 years, which has resulted in a gradual decline in soil fertility and structure. The CATC group is made up of a number of innovative farmers who are early adopters of technology and who all share a common goal to become more economically and environmentally sustainable.

All of the CATC group members are following a similar path in the transition from conventional cultivation farming to Controlled Traffic Farming (CTF); however they are all at slightly different stages in that process.

The area farmed by CATC group members is approximately 6,500 ha and of this area 4,132 ha has been fully converted to CTF.

Historical Practices

As a general summary of the group members, the traditional farming practices were:

- Cultivating the soil 4 – 6 times during the fallow period.
- A full disturbance planting.
- In crop sprays of 1-2 applications.
- Harvest plus a chaser bin.
- No uniformity in wheel base widths and no uniformity to wheel tracks.
- Burn stubble soon after harvest.
- Up to a third of the land in long fallow.

Current Practices

The transition that is occurring amongst the group is based on the following set of assumptions:

- No cultivations during the fallow period.
- 2- 4 fallow sprayings.
- Retain maximum stubble during fallow.
- Direct drill planting with minimal soil disturbance.
- All workings on tram tracks where possible. Most members have or are converting their tractors to a uniform wheel spacing (3 metres seemed to be the most common width).
- The width of the planter and harvester are generally configured to be the same and the spray rig is often double or triple that width, this allows the majority of the traffic in the paddock to be confined to the allocated wheel tracks.
- Because of the increased moisture (higher infiltration and greater storage) in the soil profile there is generally a higher cropping frequency than with the old system.

Future Practices

The next fundamental step is to implement high precision guidance to maximise the benefits of the CTF system. With higher precision guidance there is a raft of additional management options and

benefits to farmers including; selective band spraying, more crop rotation options, higher water use efficiency and higher cropping frequency.

ENVIRONMENTAL BENEFITS

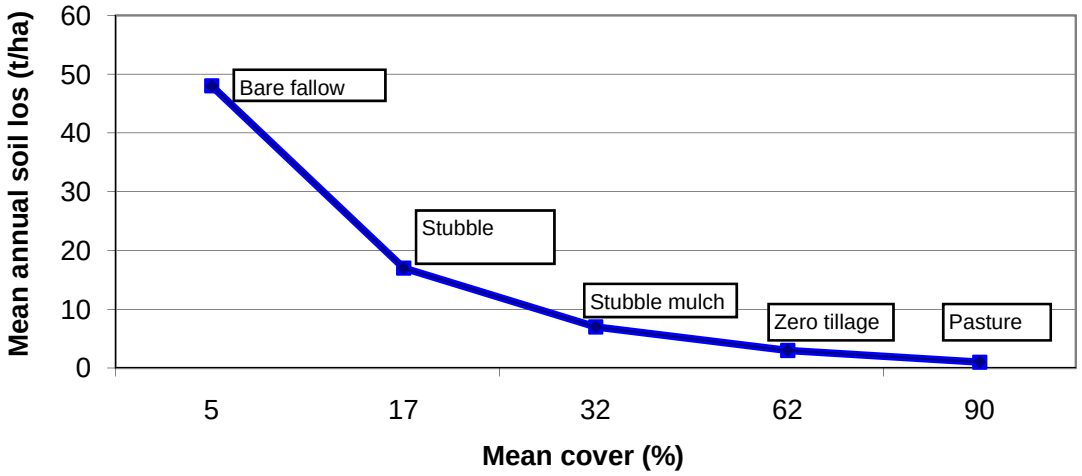
The change in farming systems by the CATC group members will undoubtedly have a number of environmental outcomes most of which will be beneficial to the Condamine Catchment. However attempting to quantify these benefits is more of a challenge.

Reduced Soil Loss/Erosion

One of the most noticeable affects of the move to CTF/No-Till is the reduction in erosion and subsequent soil loss from the properties. Between 20 and 30% soil cover reduces soil loss movement by 80-90% (Freebairn 2004) as graphically represented in Figure 1.

Reducing soil loss has several benefits:
- Cleaner water (i.e. less sediment) in the river systems,
- Less chemical and fertiliser residues in the river systems, and
- Less loss of top soil from the farmers property resulting in better productivity.

Table 1: Annual Average Soil Loss



.Figure redrawn from (Freebairn & Wockner 1991)

Therefore to quantify the reduction in soil loss as a result of the CATC group members implementing a change from conventional farming to conservation farming I will use the following assumptions:

The average starting point for the CATC group with regard to soil loss (refer to Figure 1) is somewhere between bare fallow (48 t/ha) and stubble incorporated (17 t/ha). For this report I will adopt a starting soil loss figure of 33 t/ha.

Because the majority of the CATC group members are early adopters I will assume that the soil loss as a result of implementing conservation practices is at the zero tillage point on the figure 1, which is 3 t/ha.

Therefore the total reduction in soil loss as a result of implementing conservation farming practices is 195,000 ton per annum (based on 6,500 ha with an annual soil loss saving of 30 t/ha).

Reduced Fuel Usage

One of the big savings in CTF is the reduced number of cultivation workings because weeds in the fallow stage are sprayed rather than cultivated. The main environmental benefits of this are related to a substantial reduction in the use of diesel fuel and repairs to machinery.

The average historical practices of the group were 4 full tillage cultivations plus 1 planting with full disturbance. The current practices as a result of implementing changes are 4 fallow sprays and 1 minimal disturbance planting.

The following assumptions used in this exercise are sourced from (Harris 2005):

- Fuel usage per kilowatt (KW) of tractor power per hour is equal to 0.25 litres.
- The average tractor size used by the group is 188 KW.
- The average speed for cultivating is 4.5 hectares per hour.
- The average fuel usage for cultivations is 10.4 litres per hectare.
- The average speed for spraying is 20 hectares per hour.
- The average fuel usage for spraying is 2.3 litres per hectare.

Table 2 – Estimated fuel usage under different farming systems

Details	Conventional	Zero Till - CTF	Saving
Number of workings *	5	1	**4**
Number of fallow sprays	0	4	**-4**
Fuel usage per ha	52	20	**32**
Total fuel used by group (l)	338,000	130,000	**208,000**

* The number of workings includes one planting activity.

This analysis finds that there is an average reduction of 208,000 litres of diesel fuel used per year by the CATC group members. (I have not made any allowance for the improved fuel efficiency by driving on the compacted tram tracks).

Reduction in Fertiliser and Chemical Pollutants Entering the Waterways

As discussed earlier, the Zero Tillage and CTF systems are designed to reduce soil and water runoff from the paddock. Therefore there will be less fertiliser nutrients and chemical pollutants leaving the paddock and entering the river catchment.

The Zero Tillage and CTF systems are estimated to have a 30% higher fertiliser requirement than the conventional system because we have allowed for a 20% higher cropping frequency and a 10% improvement in crop yield. However the total amount of fertiliser residue leaving the property and entering the catchment will be less because of the substantial reduction in soil sediment loss as calculated earlier in the report.

This process would be very similar for calculating the potential residue loss from any chemical applications. The reduction in soil loss with conservation farming is the predominate factor in determining the potential reduction in fertiliser or chemical residue leaving the property.

To estimate the amount of Nitrogen (N) residue that could be susceptible to run off from the property we have to consider how much N is applied, how much is likely to be used by the plant and how much is remaining in the soil. One of the accepted method for calculating the N requirement for a crop (as reported by DPI and CSIRO) is to estimate the target yield and protein of the crop and then times these by 1.75 for wheat and 1.60 for sorghum and barley. Because only about 50% of the available soil N ends up in the harvested grain you would times the N requirement by 2.

Table 3: Example of N Requirements for a Conventional and CTF System

Details	Conventional	Conservation
Yield (t/ha)	2.5	2.75
Protein (%)	12.5%	12.5%
N Removed in grain (kg/ha) *	55	60
N Needed (kg/ha)	110	120
N Available for loss (kg/ha)	55	60

* N removed in grain = yield * protein * 1.75

After the crop is harvested 50% of the N applied is still within the top profile of the soil and potentially susceptible to loss from soil and water run-off. If we assumed that under the conventional farming system that up to 33% of the unused N left the property in eroded top soil, there would have been a total loss of N into the catchment from the CATC group members of 119 ton (i.e. 55 kg/ha * 1/3 * 6500 ha).

However, under the conservation system the soil loss is reduced by up to 14 times of the conventional farming system (i.e. from 42 t/ha with conventional to 3 t/ha with conservation). Therefore the potential amount of N being lost from the properties and entering the catchment under the conservation system for the CATC group members is estimated to be 9 ton (i.e. 60 kg/ha * 1/3 * 6500 ha)/14.

Therefore the estimated environmental benefit relating to reduced N residue entering the catchment from the CATC group members is 110 ton of N per annum.

Carbon Emissions

Peter Grace from the Institute for Sustainable Resources (ISR) a Department of QUT has developed a greenhouse gas calculator for the cotton industry (http://www.isr.qut.edu.au/tools/index.jsp). This model should work equally for any cropping activity in the given region.

The model indicates that for every 1,000 litres of fuel used that there is 2.7 ton of carbon dioxide (CO^2) emitted and for every 1 ton of nitrogen fertiliser used there 2.4 ton of CO^2 emitted. Therefore if the CATC group are saving 208,000 litres of fuel per annum they are saving approximately 562 ton of CO^2 or 152 ton of carbon (i.e. the carbon component of CO^2 is approximately 27%) emissions per annum.

In the analysis we have ascertained that there has been a potential reduction in N loss from the properties of 110 ton which equates to a saving of 264 ton of CO^2 emissions or 71 ton of carbon.

Summary of Environmental Benefits

The environmental benefits of changing farming practices from a conventional tillage system to a conservation system are many. The most difficult challenge is in quantifying the benefits and then trying to place a value on them.

Table 4: A summary of the Environmental Benefits of Converting from Conventional to Conservation Farming

Indicator	Conventional		Conservation		Benefit	
	Per Ha	Group	Per Ha	Group	Per Ha	Group
Soil Loss (tons)	33	273000	3	195000	30	195000
Fuel Usage (litres)	52	338000	20	130000	32	208000
Nutrient Loss (kg)	18.30	119000	1.3	9000	17	110000
Fuel - CO^2 Loss (t)	0.23	913	0.1	351	0.12	562
N - CO^2 Loss (t)	0.044	286	0.003	22	0.040	264

THE ECONOMIC BENEFITS OF CONVERTING TO CTF

The costs to convert to a CTF system will vary from farm to farm depending on what combination of tractors and equipment farmers currently own and what level of compatibility they wish to achieve across their machines.

Quantifying the direct benefits of converting to a CTF system is not easy to pinpoint, but there are numerous anecdotal reports, as listed below.

Reduced Overlap and Reduced Input Costs

The main benefit with reduced overlap is coming with the transition from zero tillage to CTF rather than from conventional cultivation to zero tillage. Accurate positioning of each operation under CTF, has been shown to reduce the area and consequently the inputs required, by the order of 15-30% (Chapman and Powell 1998).

Table 5: Effect of a 15% Reduction in Overlap with CTF

Details	Zero Till	CTF (15% saving)	Savings Per Ha	Savings CATC Group
Seed ($/ha)	34	30	4	$16,528
Fertiliser ($/ha) *	124	108	16	$66,112
Chemical ($/ha) **	89	77	12	$49,584
Total	**247**	**215**	**32**	**$132,224**

The CATC group $ savings relate to 4,132 ha of land being converted to CTF.
* Fertiliser based on applying 120 kg/ha of urea @ $900/ton.
** Chemical based on applying 5 l/ha roundup @ $12.5/l & $15/ha for an in-crop spray.

The CATC group should receive an annual reduction in crop input costs for converting to the CTF system of around $32/ha or $132,224 per annum (based on 4,132 ha).

The seed and fertiliser costs for conventional farming system would have been the same as for zero till in the above table ($158/ha) and the chemical cost would have been $15/ha for one in-crop spray.

Reduced Compaction and Increased Ground Cover Leads to Increased Yield

The combination of less traffic in the cropping zone promotes better soil structure and increased stubble cover from zero tillage ultimately allow more moisture to enter and be retained in the soil. These combined practices can lead to crop yields increasing by an estimated 10 - 30%.

A 10% improvement in crop yield would produce an additional 1,033 ton of grain per annum for the CATC group, which at a price of $200/ton equates to $206,600.

Greater Cropping Frequency

Because there is more moisture retained in the profile there is greater potential for opportunity cropping, this could increase the annual cropped area by 10 - 40%.

Based on evidence from CATC group members and from various research we will adopt a 20% increase in cropping frequency from 80% with a conventional system to 100% with a CTF system. A 20% increase in cropping frequency equates to a potential increase in gross income for the CATC group of $478,006 (i.e. an extra 827 ha * $578ha).

Less Yield Variability Leads to Higher Grain Prices

In drier years the yields from the CTF system are historically higher than with conventional farming as are the grain prices. This can allow the option to be more proactive with grain marketing and the opportunity to capitalise on higher grain prices during drier year, which could result in 5- 20% higher grain prices on average.

To be conservative we have worked on a 5% improvement in grain prices. A 5% improvement in grain prices (i.e. $200/t + 5% = $210) equates to a potential increase in gross income for the CATC group of $113,630 (i.e. 11,363 ton * $10/t).

Less Fuel and Oil Usage

As discussed in the environmental analysis the estimated fuel usage for the conventional farming system was 52 litres/ha and 20 litres/ha for the CTF system. If we value the fuel at $1.60 per litre there is an annual saving of $51/ha or $210,732.

Fewer Repairs and Maintenance

The repairs and maintenance figures normally reduce quite markedly with CTF systems because there are fewer tractor hours and less horsepower required than with a conventional farming system.

For this analysis I will adopt the repairs and maintenance figures calculated by (Harris 2005).

Conventional –

4 cultivations @ $3.05/ha	= $12.22 (an average of a chisel plough and a cultivator)
1 planting @ $3.54/ha	= $3.54
1 spray @ $0.72/ha	= $0.72
Total	**= $16.48**

CTF -

4 fallow sprays @ $0.72/ha	= $2.88
1 planting @ $3.81/ha	= $3.81
1 spray @ $0.72/ha	= $0.72
Total	**= $7.41**

Therefore there is potentially a reduction in the repairs and maintenance expense of $37,477 across the group (i.e. based on a $9.07/ha saving over 4,132 ha).

Less Labour Required

With the conventional farming system they cultivated the ground 4 times plus had a planting. The speed of operations as established in the earlier section was 4.5 ha per hour which means that it would take 918 hours to complete the group area of 4,132 ha. Because there were 5 working in total there was a labour requirement of 4,590 hours and if we valued that at $20/hr the total labour costs were $91,800.

With the CTF system there were 4 fallow sprays at a rate of 20 ha per hour for a total time of 826 hours plus one planting of 918 hours equals a total labour requirement of 1,744 hours valued at $20/hr = $34,880. Therefore the annual saving in labour across the CATC group is potentially $56,920.

Selective Spraying

The CTF system provides the opportunity for more accuracy with regard to operations such as selective spraying, shielded spraying and band spraying. Having these options can reduce the area of the paddock that needs to be sprayed by as much as 50%. Often the herbicides used for band spraying are more selective which means they are generally also the most expensive chemicals.

Even though this is a recognised benefit with CTF I have not attached any dollar benefits to it in this analysis.

Greater Cropping Options

Another benefit with having a CTF system is that there are a number of double cropping and rotational cropping options that would not have been available with a conventional farming system. These options are available because the operator has greater control over the accuracy of seed and chemical placement. This does provide a distinct benefit to the grower but once again I have not attempted to attach any dollar benefit in this analysis.

Capital Costs to Convert to CTF

The costs to convert to a CTF system from a conventional system will vary from farm to farm depending on what combination of tractors and equipment farmers currently own and what level of compatibility they wish to achieve across their machines.

I have selected the main modifications and equipment upgrades that members of the group have undertaken and then apportioned a costing to represent an average across the group. I have then tried to rationalise how much of this upgrade was specifically for CTF

Table 6: A Summary of the Average Cost of the CATC Group Members to Convert to a CTF System

Item	**Cost**	**CTF %**	**CTF Capital**
Upgrade tractor	$200,000	20%	$40,000
Upgrade planter	$50,000	100%	$50,000
Widen wheel base's to 3 metres	$22,000	100%	$22,000
Upgrade spray rig	$50,000	50%	$25,000
Total	**$170,000**	**44%**	**$137,000**

Based on the assumptions in the table above the CATC group members have spent an average of $137,000 in capital expenditure towards converting to a CTF system.

SUMMARY OF THE ECONOMIC BENEFITS

In Table 4 I have summarised the economic outcomes in the form of a gross margin comparison between a conventional farming system and a CTF system for the CATC group members.

Table 7 - A Summary the Economic Impacts of CTF on the CATC Group

Details	Conventional		CTF		Change
	$/ha	Group	$/ha	Group	%
Area (ha)	1	3305	1	4132	**+ 20%**
Average Yield (t/ha)	2.5	2.5	2.75	2.75	**+ 10%**
Total Tons (t)	2.5	8262	2.75	11,363	
Average Price ($/t)	$200	$200	$210	$210	**+ 5%**
Income	**$500**	**$1,652,500**	**$578**	**$2,386,230**	**+ 44%**
Seed/Fertiliser/Chemical	$173	$571,765	$215	$888,380	+ 55%
Fuel & Oil	$83	$274,976	$32	$132,224	- 52%
Repairs & Maintenance	$16	$52,880	$7	$28,924	- 45%
Labour	$22	$73,400	$8	$33,056	- 67%
Contract Harvest	$40	$132,200	$40	$165,280	+ 25%
Production Costs	**$334**	**$1,105,221**	**$302**	**$1,247,864**	**+ 12%**
Crop Gross Margin	**$166**	**$547,279**	**$276**	**$1,138,366**	**+ 108%**
CTF Annual Allowance *		$0	$53	$220,000	
Total Gross Margin	**$166**	**$547,279**	**$223**	**$918,366**	**+ 68%**

* The CTF capital costs relate to 16 group members spending an average of $137,000 per group member in their conversion to a CTF farming system for a total cost of $2,200,000. We have included an annual replacement allowance of 10% or $220,000.

Findings from the Economic Analysis

- The collective benefits of increased cropping frequency, increased yield and improved grain prices have the potential to improve the gross income of the group by 44% or $733,730.
- The cost of chemicals was understandably dearer under the CTF system and this was largely offset by the higher fuel and repair costs under the conventional system.
- The total production costs ended up being about 12% higher for the CTF system even though the production costs on a per hectare basis were $302 for CTF and $378 for conventional. The main reason for this is that the 20% saving in costs was offset by a 20% increase in the cropped area.
- An annual allowance of $220,000 for the costs to change to a CTF system has been included in the analysis.
- The total potential economic gain from converting to a CTF system for the CATC group is $371,087. On an individual group member basis the economic gain is $23,193 (based on 16 group members), which represents a 17% Return On Capital invested (i.e. $137,000 invested per group member). Therefore the payback period on the $137,000 investment is approximately 5.9 years (assuming all of the stated benefits are available from day one).
- The combined benefits of the CTF system have the potential to nearly double the profit level for the group members businesses.